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**ACHARYA N. G. RANGA AGRICULTURAL UNIVERSITY**

**B.Tech (Food Technology)**

**Course No.: FDEN 224**

**Credit Hours: 3 (2+1)**

# **Food Packaging**

**STUDY MATERIAL**

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## Department of Food Engineering

Course No : **FDEN-224**

Title : **Food Packaging**

Credit hours : **3 (2+1)**

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## Lecture No. 1

*Introduction to Food Packaging – Packaging situation in World and in India – Developments in Indian Packaging – Definition of Packaging – Package, Packaging, Packing*

### ***Introduction to food Packaging:***

In today's society, packaging is pervasive and essential. It surrounds, enhances and protects the goods we buy, from processing and manufacturing, through handling and storage, to the final consumer. Without packaging, materials handling would be a messy, inefficient and costly exercise and modern consumer marketing would be virtually impossible. The packaging sector represents about 2% of Gross National Product (GNP) in developed countries and about half of all packaging is used to package food.

### ***Packaging situation in world:***

1. The size of packaging industry world wide is US \$ 600Bn (2002 – 03) (Excluding machinery).
2. US packaging market accounts for about 24%.
3. Western European packaging industry is dominated by Germany, France, Italy & UK.
4. Paper and Board leads with 36% of the world market followed by plastics.
5. World packaging industry is growing at a rate of 3-5% per annum.

### ***Packaging situation in India:***

1. The Indian market for all types of packaging materials is estimated variedly between Rs.280–300 billion per annum. Of this, consumer packaging market has been estimated at around Rs.148 billion (Table 1).

**Table 1.** Market for consumer packaging: India (2002–03)

| Product            | Value (Rs. Billion) |
|--------------------|---------------------|
| Flexible packaging | 32                  |
| Rigid plastics     | 28                  |
| Printed cartons    | 24                  |
| Glass Bottles      | 16                  |
| Metal cans         | 11                  |
| Caps and closures  | 10                  |
| Labels             | 6                   |
| others             | 21                  |
| <b>Total</b>       | <b>148</b>          |

**Note:** The above excludes bulk packaging, tiny sector and plain films

***Developments in Indian packaging:***

1. Metal cans and glass bottles have lost large markets to rigid and flexible plastics and printed monocartons.
2. Flexible packaging has replaced all forms of rigid packaging. The flexible packaging segment has seen many new innovations. The concept of the single use unit pack is now globally acknowledged as a marketing first.
3. Laminate tube has almost entirely replaced the aluminium collapsible tube for toothpaste packaging, now making inroads into the pharmaceutical sector.
4. PET bottles & Jars have made a spectacular entry into the Indian market, recording annual growth rates in excess of 20% per annum; in its wake, the demand for a whole new range of plastic closures has also emerged replacing metal closures.

PET bottles are used for mineral water, edible oil, carbonated soft drinks and a host of other products.

***Definition of packaging:***

*Packaging* has been defined as a socioscientific discipline which operates in society to ensure delivery of goods to the ultimate consumer of those goods in the best condition intended for their use.

The Packaging Institute International (PII) defines packaging as the enclosure of products, items or packages in a wrapped pouch, bag, box, cup, tray, can, tube, bottle or other container form to perform one or more of the following functions: containment, protection, preservation, communication, utility and performance. If the device or container performs one or more of these functions, it is considered a package.

Other definitions of packaging include a co-ordinated system of preparing goods for transport, distribution, storage, retailing and end-use, a means of ensuring safe delivery to the ultimate consumer in sound condition at optimum cost, and a techno-commercial function aimed at optimizing the costs of delivery while maximizing sales.

***Package, Packaging, Packing:***

It is important to distinguish between the words "package," "packaging" and "packing." The package is the physical entity that contains the product. Packaging was defined above and in addition, is also a discipline. The verb "packing" can be defined as the enclosing of an individual item (or several items) in a package or container.

## Lecture No. 2

*Need of Packaging food – Logistics – Merchandising Outlets – Handling – Transportation – Packaging machinery – Technology upgradation – Public Distribution – Cost effective packaging.*

The poor quality of packaging food in India is realized only in the context of export promotion, where, it happens to be one of the major stumbling blocks. But not much can be done about it as long as the exports of products in consumer packages continue to be a small fraction of the total exports. To achieve this, the country has to take a quantum jump in packaged distribution of foods within the country.

The problems of packaging in the country are quite complex. But these problems are solvable provided there is a desire and willingness to meet the situation squarely and by taking the remedial action. Some of the problem areas connected with packaging is as follows.

### Logistics

The essential goods have to be moved through 6,23,000 km of surfaced roads and 60,900 km of Government Railways. Overseas trade will have to be moved through sea and air. The tonnages moved across the country are enormous. For example:

|         |      |                            |
|---------|------|----------------------------|
| By road | 81   | freight (Million tonne-km) |
| By rail | 156  | freight (Million tonne-km) |
| By air  | 48.1 | freight (Million tonne-km) |

### Merchandise Outlets

The country comprises 5,76,000 villages in addition to 3,300 towns. The number of shop outlets to be serviced becomes quite obvious. Self-service stores are unknown and goods are traded across the counter.

### Handling

The availability of manual labour coupled with the problem of unemployment provides for relatively inexpensive labour and, therefore, manual handling dominates the scene.

### Transportation

The movement of goods from villages to towns, where the markets are, uses the bullock carts. Thereafter trucks and rail wagons take over. Two major systems of railways exist, one with the broad gauge and the other metre gauge. Economic operation of transport systems demands multiple numbers of transshipments involving handling and storage. Lack of adequate storage facilities has added to the problem.



### **Packaging Machinery**

The development of packaging machinery industry can be termed to be a development of the 70s. Here again the number of large producers are few but the small ones are many.

### **Technology Upgradation**

Most of the packaging industries are in the small scale sector and can not afford their own R & D. Those that are in the organized sector are unable to utilise their capacities fully and create a surplus which can be invested in research and development. In this situation, the technology has stagnated to the detriment of economic development. No efforts have been made to provide the infrastructure for technology upgradation on the scale required to meet the needs by setting up package testing and development laboratories in distant parts of the country where there is packaging industry concentration. As a result, whatever 'quality' is possible as it is understood is produced and used with the same extent of ignorance. Many times the packages fail and the goods cannot even reach the destination let alone promote consumption.

### **Public Distribution**

In a situation where one may not prefer to promote branded distribution of essential commodities and yet with a view to offering a low cost product to the poor, the Government has chosen to adopt a public distribution system. But here again, packaging which can help minimize losses and damages down the line is not taken advantage of it but is considered to be an addition to the cost and not part of the product. The country therefore suffers not only the losses in distribution but also more significantly the cost to the consumer in terms of short-weights. Staggering estimates have been made loss to the consumer through short weights.

### **Cost Effective Packaging**

On the plea that India is poor and that therefore consumers cannot afford packaged foods, it must be mentioned that industry and trade had not hitherto shown that dynamism to help the cause of consumer protection through improved packaging.

Happily the challenge has now been taken by the leading national cooperatives and among them it is difficult not to mention the Amul experience. The modern packaged distribution of fairly long-life milk by Amul at a cost below the retail market price in the distant parts of India has come as an eye opener to many and an extension of this concept to other commodities is now being examined by those who had not discovered the proper role of packaging till yesterday. India offers a vast potential for the introduction of modern technologies provided the right policies can

support their introduction, and such support has also been witnessed in the marginal duty relief given on the packaging material for milk foods in the recent budget.

A beginning is also seen in the packaged distribution of edible oils, though not in the ideal packaging form, but the acceptance of the fact that packaging can be used to mitigate the problems of the poor is in itself a good beginning.

### Lecture No. 3

*Levels of packaging – Functions of packaging –Packaging environments – Functions/ Environment grid*

#### **Levels of Packaging:**

A *primary package* is the one which is in direct contact with the contained product. It provides the initial, and usually the major protective barrier.

**Example:** Metal cans, paperboard cartons, glass bottles and plastic pouches, aerosol spray can, Beverage can, cushioning envelopes, plastic bottles, skin pack.

A *secondary package* contains a number of primary packages. It is outside the primary packaging perhaps used to group primary packages together. It is the physical distribution carrier and is sometimes designed so that it can be used in retail outlets for the display of primary packages. Ex. Corrugated case, Boxes

A *tertiary package* is made up of a number of secondary packages. It is used for bulk handling. Example being a stretch-wrapped pallet of corrugated cases.

A *quaternary package* is frequently used to facilitate the handling of tertiary packages. This is generally a metal container up to 40 m in length which can be transferred to or from ships, trains, and flatbed trucks by giant cranes. Certain containers are also able to have their temperature, humidity and gas atmosphere controlled. This is necessary in particular situations such as the transportation of frozen foods, chilled meats and fresh fruits and vegetables.

#### **Functions of packaging:**

Packaging has four primary functions i.e. containment, protection, convenience and communication.

##### **1. Containment:**

All products must be contained before they can be moved from one place to another. The "package", whether it is a bottle of cola or a bulk cement rail wagon, must contain the product to function successfully. Without containment, product loss and pollution would be wide spread.

The containment function of packaging makes a huge contribution to protecting the environment from the myriad of products which are moved from one place to another. Faulty packaging (or under packaging) could result in major pollution of the environment.

##### **2. Protection:**

This is often regarded as the primary function of the package: to protect its contents from outside environmental effects, such as water, moisture vapour, gases,

odours, micro-organisms, dust, shocks, vibrations and compressive forces, and to protect the environment from the product.

For the majority of food products, the protection afforded by the package is an essential part of the preservation process. For example, aseptically packaged milk and fruit juices in paperboard cartons only remain aseptic for as long as the package provides protection. Likewise, vacuum packaged meat will not achieve its desired shelf life if the package permits oxygen to enter. In general, once the integrity of the package is breached, the product is no longer preserved.

Packaging also protects or conserves much of the energy expended during the production and processing of the product. For example, to produce, transport, sell and store 1 kg of bread requires 15.8 MJ (mega joules) of energy. This energy is required in the form of transport fuel, heat, power and refrigeration in farming and milling the wheat, baking and retailing the bread and distributing both the raw materials and the finished product. To produce the low density polyethylene (LDPE) bag to package a 1 kg loaf of bread requires 1.4 MJ of energy. This means that each unit of energy in the packaging protects 11 units of energy in the product. While eliminating the packaging might save 1.4 MJ of energy, it would also lead to spoilage of the bread and a consequent waste of 15.8 MJ of energy.

### **3. Convenience:**

Trend towards "grazing" (i.e., eating snack type meals frequently and on-the-run, rather than regular meals), the demand for a wide variety of food and drink at outdoor functions such as sports events and leisure time, have created a demand for greater convenience in household products. The products designed around principles of convenience include foods which are pre-prepared and can be cooked or reheated in a very short time, preferably without removing them from their primary package. Sauces, dressings and condiments that can be applied simply through aerosol or pump-action packages minimize mess. Thus packaging plays an important role in meeting the demands of consumers for convenience.

Two other aspects of convenience are important in package design. One of these can best be described as the apportionment function of packaging. In this context, the package functions by reducing the output from industrial production to a manageable, desirable "consumer" size. Thus, a vat of wine is "apportioned" into bottles, a churn of butter is "apportioned" by packing into 25 ml packet and a batch of ice cream is "apportioned" into 2 L plastic tubs.

An associated aspect is the shape (relative proportions) of the primary package with regard to consumer convenience (Ex., easy to hold, open and pour as appropriate) and efficiency in building into secondary and tertiary packages. In the

movement of packaged goods in interstate and international trade, it is clearly inefficient to handle each primary package individually. Here, packaging plays another very important role in permitting primary packages to be unitized into secondary packages (Ex., placed inside a corrugated case) and secondary packages to be unitized into a tertiary package (Ex., a stretch-wrapped pallet). This unitizing activity can be carried a stage further to produce a quaternary package (Ex., A container which is loaded with several pallets). As a consequence of this unitizing function, handling is optimized since only a minimal number of discrete packages or loads need to be handled.

#### **4. Communication:**

A package functions as a "silent salesman". The modern methods of consumer marketing would fail were it not for the messages communicated by the package. The ability of consumers to instantly recognize products through distinctive branding and labeling enables supermarkets to function on a self-service basis. Without this communication function (i.e., if there were only plain packs and standard package sizes), the weekly shopping expedition to the supermarket would become a lengthy, frustrating nightmare as consumers attempted to make purchasing decisions without the numerous clues provided by the graphics and the distinctive shapes of the packaging.

Other communication functions of the package are equally important. Today the widespread use of modern scanning equipment at retail checkouts relies on all packages displaying a Universal Product Code (UPC) that can be read accurately and rapidly. Nutritional information on the outside of food packages has become mandatory in many countries.

But it is not only in the supermarket that the communication function of packaging is important. Warehouses and distribution centers would (and sometimes do) become chaotic if secondary and tertiary packages lacked labels or carried incomplete details. When international trade is involved and different languages are spoken, the use of unambiguous, readily understood symbols on the package is imperative. UPC's are also frequently used in warehouses where hand-held barcode readers linked to a computer make stock-taking quick and efficient. Now the use of radio frequency identification (RFID) tags attached to secondary and tertiary packages is beginning to revolutionize the supply chain.

#### **Package environments:**

The packaging has to perform its functions in three different environments. Failure to consider all three environments during package development will result in

poorly designed packages, increased costs, consumer complaints and even avoidance or rejection of the product by the customer.

### ***1. Physical environment:***

This is the environment in which physical damage can be caused to the product. It includes shocks from drops, falls and bumps, damage from vibrations arising from transportation modes including road, rail, sea and air and compression and crushing damage arising from stacking during transportation or storage in warehouses, retail outlets and the home environment.

### ***2. Ambient environment:***

This is the environment which surrounds the package. Damage to the product can be caused as a result of gases (particularly O<sub>2</sub>), water and water vapour, light (particularly UV radiation) and temperature, as well as micro-organisms (bacteria, fungi, molds, yeasts and viruses) and macro organisms (rodents, insects, mites and birds). Contaminants in the ambient environment such as exhaust fumes from automobiles and dust and dirt can also find their way into the product unless the package acts as an effective barrier.

### ***3. Human environment:***

This is the environment in which the package interacts with people and designing packages for this environment requires knowledge of the variability of consumers capabilities including vision, strength, weakness, dexterity, memory and cognitive behaviour. Since one of the functions of the package is to communicate, it is important that the messages are clearly received by consumers. In addition, the package must contain information required by law such as, nutritional content and net weight.

To maximize its convenience or utility functions, the package should be simple to hold, open and use. For a product which is not entirely consumed when the package is first opened, the package should be resealable and retain the quality of the product until completely used. Furthermore, the package should contain a portion size which is convenient for the intended consumers; a package which contains so much product that it deteriorates before being completely consumed clearly contains too large a portion.

### ***Functions / Environments grid:***

The functions of packaging and the environments where the package has to perform can be laid out in a two-way matrix or grid as shown in Figure 1. Anything that is done in packaging can be classified and located in one or more of the 12 function/environment cells. The grid provides a methodical yet simple way of evaluating the suitability of a particular package design before it is actually adopted

and put into use. As well, the grid serves as a useful aid when evaluating existing packaging.

|                                           |               | Environments |         |       |
|-------------------------------------------|---------------|--------------|---------|-------|
|                                           |               | Physical     | Ambient | Human |
| F<br>u<br>n<br>c<br>t<br>i<br>o<br>n<br>s | Containemnt   |              |         |       |
|                                           | Protection    |              |         |       |
|                                           | Convenience   |              |         |       |
|                                           | Communication |              |         |       |

**Figure 1. Functions/environments grid for evaluating package performance**

## Lecture No. 4

*Shelf life of processed foods – Factors influencing shelf life – Product – package - Environment*

**Shelf life** is the length of time that foods, beverages, and many other perishable items are given before they are considered unsuitable for sale, use, or consumption. It is the time between the production and packaging of a product and the point at which the product first becomes unacceptable under defined environmental conditions. It is a function of the product, package and the environment through which the product is transported, stored and sold.

**Factors influencing shelf life:** These include product, package and the environment.

**Product:** Products differ greatly in their susceptibility to various agents. These agents cause different changes which affect the shelf life. Examples include:

1. Aroma loss as in freshly ground pepper or roasted coffee which results in loss of palatability
2. Pick up of a foreign odour. Ex. Absorption of onion odour by butter when these two items are placed together.
3. Loss of carbonation as in the case of soft drinks or beer
4. Crystallization. Ex. Honey when kept in cold for a long time.
5. Moisture gain as in dry or dehydrated foods such as ready-to-eat breakfast cereals, snack foods which destroys their crisp texture
6. Rancidity of snack items such as potato chips due to the oxidation of the oils absorbed during frying
7. Browning reactions as in case of freshly cut fruits.

**Package:** A package is meant to protect the product against an agent which degrades the product. The degree of protection is measured a water vapour transmission rate (WVTR) and oxygen transmission rate (OTR) for moisture and oxygen sensitive foods respectively.

The critical sensitivity of the product to external agents is determined in part by the package. Ex. A product such as snack food which is susceptible to moisture gain and oxygen can be termed as 'moisture sensitive' if texture degrades before rancidity becomes objectionable. The same product, if packed in a sufficient moisture barrier would become oxygen sensitive.

**Environment:** Product distribution through various network causes stress on the product under a variety of climates, seasons, shipping and warehouse conditions.



Barrier properties of the package are therefore related to the environment conditions and are summarized in Table 2. Barrier properties indicate the range of properties which play a part in determining the total protective efficiency of a package.

**Table 2. Interaction of package and environment for foods**

| <b>Environmental factor</b>      | <b>Pertinent package properties</b>      |
|----------------------------------|------------------------------------------|
| Mechanical shocks                | Strength                                 |
| Pressure of oxygen, water vapour | Permeability                             |
| Light intensity                  | Light transmission, thermal conductivity |
| Temperature                      | Porosity reflectivity                    |
| Biological agents                | Penetrability                            |

## Lecture No. 5

*Hazards of distribution — mechanical hazards — climatic hazards — other hazards*

### **Hazards of distribution**

Some changes will occur to the package on its journey to the consumer. It is necessary to know the method of transport, the probable storage conditions, and the duration of both journeys and storage. Important points to establish are:

1. The type of transport – road, rail, sea or air.
2. The degree of control over the transport – is it private or public transport?
3. The form of transport – break-bulk, freight container, postal, passenger train.
4. The mechanical conditions and duration of storage.
5. The nature and intensity of the mechanical and climatic hazards in transport, storage, retailing and use.
6. Whether handling aids are available for loading and off-lading at all points between maker and user.
7. The importance of minimum volume in relation to transport costs.

Tables 3- 5 summarize the possible hazard.

**Table 3.** Distribution hazards: mechanical hazards

| Basic hazard                  | Typical circumstances                                                                                                                                  |
|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| Impact                        |                                                                                                                                                        |
| a) Vertical                   | Package dropped to floor during loading and unloading<br>Fall from chutes or conveyors                                                                 |
| b) Horizontal                 | Result of throwing<br>Rail or road vehicle stopping and starting                                                                                       |
| Vibration                     | From handling equipment<br>Engine and transmission vibration from vehicles                                                                             |
| Compression                   | Static stacks in factory, warehouse and store                                                                                                          |
| Racking or deformation        | Transient loads during transport in vehicles<br>Uneven support due to poor floors, storage<br>Uneven lifting due to bad slinging, localized suspension |
| Piercing, puncturing, tearing | Hooks, projections, misuse of handling equipment                                                                                                       |

**Table 4.** Distribution hazards: climatic hazards

| Basic hazard     | Typical circumstances                                                                                                                             |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| High temperature | Direct exposure to sunshine<br>Proximity to boilers, heating systems etc<br>Indirect exposure to sun in sheds, vehicles etc. with poor Insulation |
| Low temperature  | Unheated storage in cold climates<br>Transport in unheated aircraft holds                                                                         |
| Low pressure     | Cold storage                                                                                                                                      |
| Light            | Change in altitude<br>Direct sunshine<br>UV exposure                                                                                              |
| Water            | Artificial lighting<br>Rain during transit, loading and unloading, warehousing and storage                                                        |
| Dust             | Exposure to wind-driven particles of sand, dust.                                                                                                  |
| Water vapour     | Humidity of the atmosphere                                                                                                                        |

**Table 5.** Distribution hazards: other hazards

| Basic hazard                               | Typical circumstances                                                                                                                                                                                             |
|--------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Biological                                 |                                                                                                                                                                                                                   |
| a) Microorganisms, fungi, moulds, bacteria | Require moisture and generally will not grow at relative humidities of less than 70%. Will grow over a wide range of temperatures.                                                                                |
| b) beetles, moths, flies, ants, termites   | In general high temperatures are more favourable for development than low ones. A relative humidity of 70% is very favourable for most insects. Infestation usually starts from eggs laid on packaging materials. |
| c) mites                                   | They develop over a lower temperature range                                                                                                                                                                       |
| d) rodents (rats, mice)                    | May be present in warehouses, transit sheds, storage areas.                                                                                                                                                       |
| Contamination by other goods               |                                                                                                                                                                                                                   |
| a) by materials of adjacent packs          | Destruction of marking printing by rusty metalwork – strapping, wire bands. Effects of damp packaging materials, especially hessian on non-water resistant materials and metal parts.                             |
| b) by leaking contents of adjacent packs   | Damage to containers of liquids, powders and granulated substances may result in leakage of the contents. The                                                                                                     |

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effect of the resultant contamination on adjacent packs can range from the spoiling of external appearance to complete disintegration of a pack and its contents, depending on the nature of the contaminant, the packing materials and the contents of the pack contaminated.

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## Lecture No. 6

### *Factors influencing shelf Life of fruits and vegetables –Respiratory Metabolism*

#### **Factors influencing shelf Life of fruits and vegetables:**

Several factors influence shelf life of fruits and vegetables. These factors can be conveniently categorized as internal and external factors. Internal factors relate to the type and nature of plant tissues i.e. dormant mature or senescent; and whether root fruit, leaf or flower etc. Physiological maturity of fruits and vegetables at the time of harvesting affects the shelf life to a great extent. Hence, harvesting should be done at optimum maturity level as far as possible.

The shelf life of a properly harvested sound produce depends largely on storage as well as post storage (marketing conditions). Thus storage as well as post storage atmospheres (i.e. temperature, relative humidity and the composition of air surrounding the produce) become the key factors governing shelf life. Among the various factors affecting the shelf life, factors pertaining to storage atmosphere can be manipulated to a great extent to increase the shelf life of a product.

Various metabolic processes, which continue to take place in the produce even after harvest, affect the shelf life of the produce. Among these, respiration is considered to be the major metabolic process which brings about natural ageing and subsequent deterioration of the produce. In the process of respiration,  $O_2$  from the surrounding atmosphere is taken by the produce for oxidative reduction of respiratory substrates (viz., carbohydrates, organic acids etc.) to carbondioxide and water. Carbondioxide evolved by the produce is given out to the surrounding atmosphere. The total amount of  $CO_2$  produced by the commodity throughout its post-harvest life depends largely on the quantity of substrates. Hence it is constant for a given commodity. When the commodity completes given out this constant amount of  $CO_2$  its normal life comes to an end. It is the rate of  $CO_2$  evolution, which determines the life span. Higher the rate of  $CO_2$  evolution (respiration), shorter the shelf life of the product and vice versa.

#### **Respiratory metabolism:**

Respiration involves a series of reactions through which oxidative reduction of the substrates takes place. By storing the produce in an atmosphere having higher  $CO_2$  concentration, the  $CO_2$  evolution (respiration) can be inhibited to some extent. Likewise, storing of the produce at low temperature also brings down the rate of respiration. Thus, by modifying storage atmosphere (i.e. the composition of storage

air with regard to  $O_2$  and  $CO_2$  concentrations and the temperature), respiration of the stored produce can be decreased. Consequently, post harvest life can be increased.

$CO_2$  concentration levels higher than the critical level cause flesh softening and peel discoloration in the produce while temperature lower than the critical one cause chilling injury to the produce.

## Lecture No. 7

Controlled Atmosphere Packaging Technology (CAP) – Modified Atmosphere Packaging Technology (MAP) – Advantages and disadvantages of MAP – Gases used in MAP

### ***Controlled atmosphere Packaging:***

Controlled atmosphere packaging (CAP) is the enclosure of food in a gas impermeable package inside which the gaseous environment with respect to CO<sub>2</sub>, O<sub>2</sub>, N<sub>2</sub>, water vapor and trace gases has been changed, and is selectively controlled to increase shelf life. In this technology, the storage system consists of airtight storage chambers, O<sub>2</sub> regulatory unit, CO<sub>2</sub> absorbing unit equipment for monitoring as well as controlling the chambers and composition. Liquid N<sub>2</sub> generator is commonly installed to flush and chambers with liquid N<sub>2</sub> as and when required for maintaining optimum level of O<sub>2</sub>. For maintaining optimum level of CO<sub>2</sub> in the chambers, air in chambers is circulated through CO<sub>2</sub> scrubber frequently. CO<sub>2</sub> absorbing materials such as hydrated lime, calcium or potassium hydroxides are generally used in scrubber. Refrigeration unit is employed for maintaining storage temperature.

The storage life of various fruits and vegetables can be increased by 2 to 4 times the normal life by employing Controlled Atmosphere storage technology. However, CA stored produce deteriorate rapidly when exposed to normal atmospheres during marketing. It shortens the post storage life of the produce, which eventually affects marketing. The involvement of bulky and sophisticated equipment limits the use of CA technology during transport as well as retail storing of fruits and vegetables. The construction of air tight storage and continuous monitoring as well as controlling of storage air composition make the technology cost intensive.

### ***Modified Atmosphere Packaging:***

Modified Atmosphere Packaging (MAP) can be defined as the enclosure of food in a package in which the atmosphere inside the package is modified or altered to provide an optimum atmosphere for increasing shelf life and maintaining quality of the food. Modification of the atmosphere may be achieved either actively or passively. Active modification involves displacing the air with a controlled, desired mixture of gases, a procedure generally referred to as gas flushing. Passive modification occurs as a consequence of the food's respiration or the metabolism of micro-organisms associated with the food; the package structure normally

incorporates a polymeric film, and so the permeation of gases through the film (which varies depending on the nature of the film and the storage temperature) influences the composition of the atmosphere that develops.

In controlled atmosphere storage (CAS), the gas composition inside a food storage room continually monitored and adjusted to maintain the optimum concentration within quite close tolerances. In contrast, the less common modified atmosphere storage (MAS) typically involves some initial modification of the atmospheric composition in an airtight storage room, which changes further with time as a result of the respiratory activity of the fresh food and the growth micro-organisms. Because CAS is capital-intensive and expensive to operate, it is more appropriate, for those foods that are amenable to long-term storage such as apples, kiwifruit, pears and meat.

### ***Advantages and disadvantages of Modified atmosphere packaging:***

#### **Advantages:**

1. Shelf life will be increased by 50 to 400%.
2. Reduced economic losses due to longer shelf life.
3. Provides a high quality product.
4. Centralized packaging and portion control.
5. Improved presentation – clear view of product and all –around visibility.
6. Little or no need for chemical preservatives.
7. Sealed packages are barriers against product recontamination and drip from package.
8. Odorless and convenient packages.

#### **Disadvantages:**

1. Added costs for gases, packaging materials and machinery.
2. Temperature control necessary.
3. Different gas formulations for each product type.
4. Special equipment and training required.
5. Increased pack volume adversely affects transport costs and retail display space.
6. Loss benefits once the pack is opened or leaks.
7. CO<sub>2</sub> dissolving into the food could lead to pack collapse and increased drip.



**Gases used in MAP:**

The three main gases used in MAP are CO<sub>2</sub>, O<sub>2</sub>, and N<sub>2</sub>, either singly or in combination.

**Carbon dioxide:** Carbon dioxide is the most important gas in the MAP of foods because of its bacteriostatic and fungistatic properties. It inhibits the growth of many spoilage bacteria, the degree of inhibition increasing with increasing concentration. It is particularly effective against aerobic spoilage bacteria such as *Pseudomonas* species.

The solubility of CO<sub>2</sub> increases with decreasing temperature and therefore the antimicrobial activity of CO<sub>2</sub> is markedly greater at lower temperatures. This has significant implications for MAP of foods. The high solubility of CO<sub>2</sub> in high moisture/high fat foods such as meat, poultry and seafood can result in package collapse owing to the reduction of headspace volume. High levels of CO<sub>2</sub> can also result in increased drip or exudate from flesh foods, and the addition of absorbent pads in the base of the package is used to compensate for this.

**Oxygen:** Oxygen promotes several types of deteriorative reactions in foods including fat oxidation, browning reactions and pigment oxidation. Most of the common spoilage bacteria and fungi require O<sub>2</sub> for growth. For these reasons, O<sub>2</sub> is either excluded or the level set as low as possible. Exceptions occur where O<sub>2</sub> is needed for fruit and vegetable respiration or the retention of color in red meat.

**Nitrogen:** Nitrogen is an inert gas with no odor or taste. It has a lower density than air and a low solubility in water and other food constituents, making it a useful filler gas in MAP to counteract package collapse caused by CO<sub>2</sub> dissolving in the food. Nitrogen indirectly influences the micro-organisms in perishable foods by retarding the growth of aerobic spoilage microbes but it does not prevent the growth of anaerobic bacteria.

## Lecture No. 8

Packaging laws and Regulations – SWMA Rules – PFA Rules – FPO Rules – MFPO Rules – Edible oil packaging order - AGMARK Rules

Packaging Laws and Regulations have been introduced by the Government to safeguard the interests of the consumer and the society at large. The Packaging Laws and Regulations for food products are mainly covered under:

1. The Standards of Weights and Measures Act, 1976 and the Standards of Weights and Measures (Packaged Commodities) Rules, 1977 (SWMA).
2. The Prevention of Food Adulteration Act, 1954 and the Prevention of Food Adulteration Rules, 1955 and its first amendment, 2003 (PFA).
3. The Fruit Products Order, 1955 (FPO)
4. The Meat Food Products Order, 1973 (MFPO)
5. The Edible Oil Packaging Order, 1998
6. The AGMARK Rules

### ***The Standards of Weights & Measures Act (SWMA):***

The most important rule under SWMA is that the commodities to be packed for retail should be packed in standard specific quantities as given under the rule for each commodity. However, the Central Government can authorize pre-packaging in quantities other than those specified on technical ground.

Some of the important aspects of SWMA are mentioned below.

**Standard Units:** It states that every unit shall be based on the metric system. The units to be adopted are the International System of units.

**Declaration on Packaged commodities for Interstate trade or commerce:** Every commodity in packaged form has to bear upon it, on a label securely attached to it, a definite, plain and conspicuous declaration of:

- Identity of commodity in the package
- Net quantity, in terms of the standard unit of weight or measure, of the commodity in the package
- where the commodity is packaged or sold by number, the accurate number of commodity contained in the package
- The unit sale price of the commodity in the package
- The sale price of the package

- Every package should bear the name of the manufacturer and also of the packer or distributor.

**Standard Packages:** Under the Standards of Weights and Measures (Packaged Commodities) Rules, rules have been framed specifying provisions for the retail sale of packaged goods. One of the most important rules is with respect to the requirements that specific commodities are to be packed and sold only in standard packages. As per the Third Schedule, food products and their respective package capacities are given in Table 5.

**TABLE 6. Commodities to be packed in Specified Quantities (Standard Packages) as per the Third Schedule of SWMA Rules**

| Commodities                                     | Quantities in which to be Packed                                                                                                          |
|-------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| Baby food                                       | 200 g, 500 g, 1 k g, 2 kg, 5 kg and 10 kg – Any manufacturer or packer packing baby food in 400 g and weaning food in 500 g               |
| Weaning food                                    | 200 g, 400 g, 1 kg, 2 kg, 5 kg and 10 kg – Publication of this notification in the official gazette                                       |
| Biscuits                                        | 25 g, 50 g, 75 g, 100 g, 150 g, 200 g, 250 g, 300 g and thereafter in multiples of 100 g up to 1 kg                                       |
| Bread including brown bread                     | 100 g and thereafter in multiples of 100g                                                                                                 |
| Uncanned packages of butter and margarine       | 25 g, 50 g, 100 g, 200 g, 500 g, 1 kg, 5 kg and thereafter in multiples of 5 kg                                                           |
| Cereals and pulses                              | 100 g, 200 g, 500 g, 1 kg, 2 kg, 5 kg and thereafter in multiples of 5 kg                                                                 |
| Coffee                                          | 25g, 50g, 100g, 200g, 500g, 1 kg and thereafter in multiples of 1 kg                                                                      |
| Tea                                             | 25 g, 50 g, 100 g, 200 g, 500 g, 1 kg and thereafter in multiples of 1 kg                                                                 |
| Milk Powder                                     | Below 50 g no restriction, 50 g, 100 g, 200 g, 500 g, 1 kg and thereafter in multiples of 500 g                                           |
| Rice (powdered), flour, atta, rawa and suji     | 100 g, 200 g, 500 g, 1 kg, 2 kg, 5 kg and thereafter in multiples of 5 kg                                                                 |
| Salt                                            | Below 50 g in multiples of 10 g; 50 g, 100 g, 200 g, 500 g, 750 g, 1 kg, 2 kg, 5 kg and thereafter in multiples of 5 kg                   |
| Aerated soft drinks and non-alcoholic beverages | 100 ml, 150 ml, 200 ml, 250 ml, 300 ml, 330 ml (in cans only), 500 ml, 750 ml, 1 litre, 1.5 litre, 2 litre, 3 litre, 4 litre, and 5 litre |

There are two types of commodities namely Class-A and Class-B commodities.

**Class-A commodities:**

- a) the net weight or volume of which does not exceed 25 g or 25 cc
- b) the flow properties, density or both of which can not be maintained constant except with the help of considerable special technical effort
- c) which require several operations for packaging
- d) which after they have been packed, are subject to additional processing such as heat treatment, which is likely to effect the weight of the commodities in irregular or unpredictable manner
- e) liquid commodities

**Class –B commodities** are those which does not fall under Class-A.

**General Provisions Relating to Declaration of Quantity:**

1) In declaring the net quantity of the commodity contained in a package, the weight of wrappers and materials other than the commodity shall be excluded; provided that where a package contains a large number of small items of confectionery, each of which is separately wrapped, the net weight declared on the package containing such confectionery or on the label thereof may include the weight of such immediate wrappers, if and only if, the total weight of such immediate wrappers does not exceed:

(a) 8%, where such immediate wrapper is a waxed paper or any other paper, with wax or aluminium foil (under strip), or

(b) 6%, in case of any other paper, of the total net weight of all the items of confectionery contained in the package minus the weight of immediate wrapper.

2) Where a commodity in a package is not likely to undergo any variation in weight or measure, on account of the environmental conditions, the quantity declared on the package shall correspond to the net quantity, which will be received by the consumer, and the declaration of quantity on such package shall not be qualified by the words “when packed” or the like.

3) where a commodity in package is likely to undergo variations in weight or measure on account of environmental conditions and such variation is negligible, the declaration of quantity in relation to such package shall be made after taking into account such variation so that the consumer may receive not less than the net quantity of the commodity as declared on the package, and the declaration of quantity on such package shall not also be qualified by the words “when packed” or the like.

4) The commodities which are likely to undergo significant variation in weight or measures on account of environmental or other conditions, may be qualified by the words “when packed”.

**Symbols for unit:**

The symbols for International System of units and none other, shall be used in furnishing the net quantity of the package. Symbols shall not be given in capital form except for the unit derived from a proper name, period i.e. a dot after symbols shall not be put. As far as possible, symbols shall always be written in the singular form i.e. ‘s’ shall not be added. Ex. mg, g, kg, ml, l, mm, cm, m, cm<sup>2</sup>, m<sup>2</sup>, cm<sup>3</sup>, m<sup>3</sup> etc.

**General guidelines on giving declarations:** As far as possible, all declarations required to be made under SWMA rules should appear on the principal display panel. Every declaration which is required to be made on a package should be legible, prominent, definite, plain and unambiguous and should be given in a specified minimum size depending on the area of the principal display panel.

**Violation of Law:** There is penalty for different offences. If any person packs, distributes, stores, delivers or sells commodities, which does not meet the requirements of the Act and the Packaged Commodities Rules, can be punished by a fine which may extend up to Rs.5000. If the offence is repeated, the penalty can be imprisonment of up to five years.

**The Prevention of Food Adulteration Act (PFA):**

Prevention of Food Adulteration Act was introduced by Government to prevent adulteration of food. Adulteration Act and Rules have provided standards for a large variety of food. The responsibility of adequate packaging of food and its safety falls on the manufacturer of the food product. The Prevention of Food Adulteration Act prohibits manufacture, storage and sale of adulterated food. The violation of law is prosecuted before a magistrate’s court. The punishment is mandatory imprisonment for a minimum of three months.

**Food and adulteration:** As per the Act, a food is deemed to be adulterated :

1. If the article sold by a vendor is not of the nature, substance or quality demanded by the purchaser
2. If the article contains any other substance, which affects
3. If any inferior or cheaper substance has been substituted wholly or in part for the article so as to affect injuriously the nature, substance or quality thereof.

4. If the article had been prepared, packed or kept under unsanitary conditions whereby it has become contaminated or injurious to health.
5. If the article consists wholly or in part of any filthy, putrid, rotten, decomposed or diseased animal or vegetable substance or is insect-infested or is otherwise unfit for human consumption.
6. If the article is obtained from a diseased animal.
7. If the article contains any poisonous or other ingredient which renders it injurious to health.
8. If the container of the article is composed, whether wholly or in part, of any poisonous or deleterious substance which renders its contents injurious to health.
9. If any colouring matter other than prescribed in respect thereof is present in the article, or if the amount of the prescribed colouring matter, which is present in the article are not within the prescribed limits of variability.
10. If the article contains any prohibited preservative or permitted preservative in excess of the prescribed limits.
11. If the quality or purity of the article falls below the prescribed standard or its constituents are present in quantities not within the prescribed limits of variability, but, which renders it injurious to health.

**Packaging and storage requirements:** A utensil or container made of the following materials or metals, when used in the preparation, packaging and storing of food shall be deemed to render it unfit for human consumption.

1. Containers which are rusty
2. Enameled containers which have become chipped and rusty
3. Copper or brass containers which are not properly tinned
4. Containers made of aluminium not conforming in chemical composition to IS:20 Specification for cast aluminium and aluminium alloy for utensils or IS:21 specification for wrought aluminium and aluminium alloy for utensils
5. Tin and plastic containers once used shall not be re-used for packaging of edible oil and fats.
6. The PFA Rules also stipulate that certain food items such as confectionery (weighing more than 500 grams), protein rich atta, protein rich maida, blended edible vegetable oil, coloured and flavoured table margarine, fat spread, spices and condiments shall be sold in packed condition only.

### **Other Packaging Requirements under PFA**

1. For infant milk food, infant formula milk cereal based weaning food and processed cereal based weaning food, the rules state that: The product shall be packed in hermetically sealed, clean and sound containers or in flexible packs made from film or combination of any or substrate made of board paper, polyethylene, polyester metallised film or aluminium foil in such a way so as to protect it from deterioration.
2. For meat and meat products, the product shall be packed in hermetically sealed containers and subjected to heat treatment followed by rapid cooling to ensure that the product is shelf-stable. The sealed container shall not show any change on incubation at 35°C for 10 days and 55°C for 5 days.
3. For natural mineral water, naturally carbonated natural mineral water, and packaged drinking water, the rules stipulated regarding the packaging materials are: It shall be packed in clean, hygienic, colourless, transparent and tamperproof bottles/ containers made of Polyethylene (PE) conforming to IS:10146 or Poly Vinyl Chloride (PVC) conforming to IS:10151 or Polyalkylene Terephthalate (PAT) conforming to IS 12252 or Polypropylene conforming to IS:10910 or food-grade Polycarbonate or sterile glass bottles suitable for preventing possible adulteration or contamination of the water. All packaging materials of plastic origin shall pass the prescribed overall migration and colour migration limits.

**Declarations and Labeling:** Any packaged food, which does not conform to the requirements under the PFA is deemed “**misbranded**”. As per the Act, an article of food shall be deemed to be misbranded:

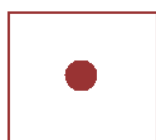
1. If it is an imitation of, or is a substitute for, or resembles in a manner likely to deceive, another article of food under the name of which it is sold, and is not plainly and conspicuously labeled so as to indicate its true character.
2. If it is falsely stated to be the product of any place or country.
3. If it is sold by a name which belongs to another article of food.
4. If it is so coloured, flavoured or coated, powdered or polished, that the fact that the article is damaged is concealed or if the article is made to appear better or of greater value than it really is.
5. If false claims are made for it upon the label or otherwise.

6. If the package containing it, or the label on the package bears any statement, design or device regarding the ingredients or the substances contained therein, which is false or misleading in any material particular; or if the package is otherwise deceptive with respect to its contents.
7. If the package containing it or the label on the package bears the name of a fictitious individual or company as the manufacturer or producer of the article.
8. If it contains any artificial flavouring, artificial colouring or chemical preservative, without a declaratory label stating that fact, or in contravention of the requirements of this Act or rules made thereunder.
9. If it is not labeled in accordance with the requirements of this Act or rules made thereunder.

Part VII of the Rules deals with the Packing and Labeling of Food. As per these rules, the following are required:

1. The name, trade name or description of food contained in the package.
2. The names of ingredients used in the product in descending order of their composition by weight or volume as the case may be. If artificial flavouring is used, the chemical names of the flavour need not be declared, but, in the case of natural flavouring substances or nature-identical flavouring substances, the common name of the flavour is to be mentioned on the pack.

If the food contains any ingredient in part or whole from animal origin (meat, fish, poultry eggs), a declaration is to be made by a symbol and a colour code stipulated for this purpose, to indicate the product as Non-vegetarian Food. The symbol should be on the principal display panel in close proximity to the name or brand name of the food. The symbol shall consist of a brown colour filled circle. Similarly, for vegetarian food a similar symbol with green colour circle and square will be displayed.



Non-vegetarian Food

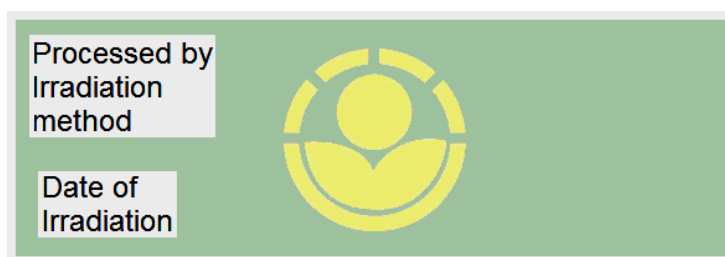


Vegetarian Food

The symbol shall be prominently displayed on the package having contrast background and in close proximity to the name or brand name of product, and also on the labels, pamphlets, leaflets, and advertisements in any media.



1. The name and complete address of the manufacturer, or importer, or vendor or packer to be declared.
2. A declaration is to be made for the net weight or number or measure of volume of content in the case of biscuits, breads, confectionery and sweets where the weight may be expressed as average net weight or minimum net weight.
3. The batch number or lot number or code number may be declared either in numericals or alphabets or in combination, preceded by the words "Batch No." or "Batch" or "Lot No." or "Lot" or any distinguishing prefix.
4. The month and year in which the product was manufactured or pre-packed is to be declared except in case of carbonated water containers and packages of biscuits containing 60 grams to 120 grams and packages of food weighing less than 60 grams, bread, milk and for all packages of irradiated food to bear the following declaration and logo:



5. The package should declare:

The month and year in capital letters up to which the product is best for consumption, in the following manner, namely:

"BEST BEFORE ..... MONTHS AND YEAR" or

"BEST BEFORE ..... MONTHS FROM PACKAGING" or

"BEST BEFORE ..... MONTHS FROM MANUFACTURE" or

"BEST BEFORE UPTO MONTH AND YEAR ....."

In case of package or bottle containing sterilised or ultra high temperature treated milk, soya milk, flavoured milk, any package containing bread, dhokla, bhelpuri, pizza, doughnuts, khoa, paneer, or any uncanned package of fruits, vegetable, meat, fish or any other like commodity, the declaration be made as follows:

" BEST BEFORE ..... DATE/MONTH/YEAR"

or

" BEST BEFORE ..... DAYS FROM PACKAGING".

**Enforcement of the PFA:** The Food Inspector has the power to take a sample of the food from the place of manufacture, storage or from seller and send it to a Public Analyst for testing. If the Analyst's report declares that the sample is not in conformity with the provisions of the PFA, the Food Inspector initiates prosecution in the court of a first class magistrate.

#### **Fruit Products Order (FPO):**

The Fruit Products Order is concerned with fruit and vegetable products including synthetic beverages, syrups, sharbats and vinegar. The objective of this law is mainly to regulate the quality and hygiene of these products.

The important labeling rule under FPO is that all labels should have the approval of the authorities concerned, and carry the license number allotted. When a bottle is used as the package, it should be so sealed that it cannot be opened without destroying the license number, and the special identification mark of the manufacturer should be displayed on the top or neck of the bottle. The batch/code number along with the date of manufacturing should also be declared.

As contained in PFA, FPO also prohibits use of any statement, design or device, which is false or misleading concerning the fruit product. Synthetic products associated with fruits and vegetables should clearly be marked "**SYNTHETIC**" and the word, "**SYNTHETIC**", whenever used, should be as bold and in the same size and colour of the letters used for the name of the product, and should immediately precede such name.

#### **Meat Food Products Order (MFPO)**

Meat Food Products Order, similar to FPO, regulates the licensing and labeling of all meat products. All labels have got to be approved by the licensing authority, and the license number and category of manufacturer should be declared on the label.

The name of the product, always a common name understood by the consumer, should be given along with net quantity. Trade names should have prior approval of the licensing authority. When any preservative or colouring agent is used, a statement to that effect should be given. When permitted artificial flavouring agent is used, the words, "**Artificially Flavoured**", should appear on the label in prominent letters and in continuance of the name of the product. The list of ingredients should also be given. Terms which may bear some geographical significance with reference to a locality other than in which either the factory is located, or the product is

manufactured, can be given on the label after being qualified by the word, “**STYLE**”, “**BRAND**”, or “**TYPE**”, as the case may be. No statement, word, picture or design, which may convey a false impression or give a false indication of origin or quality, can appear on the label.

### **Edible Oil Packaging (Regulation) Order, 1998**

In order to ensure availability of safe and quality edible oil in packed form, the Central Government promulgated on 17th September, 1998 a Packaging Order under the Essential Commodities Act, 1955 to make packaging of edible oil, sold in retail, compulsory unless specifically exempted by the concerned State Governments.

Uniform methods for testing the quality of edible oil, including the Thin Layer Chromatography (TLC) method for detection of Argemone oil was prescribed and circulated to all State Governments and manufacturers.

### **Agricultural Grading & Marking (AGMARK) Rules:**

AGMARK rules relate to the quality specifications and needs of certain agricultural products to be eligible for Agmark Certification. They also specify the type of packages that can be used for various products and labeling declarations that have to be given. Some of the food products that have been covered under these rules are edible nuts, ghee, honey, pulses, spices and condiments and vegetable oil.

## Lecture No. 9

*National Standards on Packaging code for foodstuffs and Perishables – Classification of food stuffs according to the BIS code – Packaging of milk and milk products*

With the growth in the food industry, there is also a growing demand for packaging materials. Selection and use of the right material and the role it plays in preservation and protection of perishable products and foodstuffs has become very important. For perishables such as meat, fish, fruits and vegetables which are stored and transported under refrigeration or in frozen condition, proper maintenance of a cool or cold chain is imperative.

Bureau of Indian Standards (BIS) has brought out a series of Indian Standards on Packaging codes. IS:10106 (Part 1 Sec 1):1990 is one such Indian Standard on packaging code where Part 1 deals with the product packaging and under section 1, it covers Foodstuffs and Perishables. This code has classified foodstuffs and perishables in categories of decreasing order of perishability and la i

### **Classification of food stuffs according to BIS code:**

The BIS code has classified foodstuffs and perishables into the following categories in their decreasing order of perishability.

1. Milk and milk products
2. Fruits and vegetables
3. Meat, Fish and Poultry
4. Bakery rich foods
5. Protein rich foods
6. Edible starches and starch products
7. Oils and fats
8. Foodgrains and foodgrain products
9. Sugar and honey
10. Stimulant foods
11. Alcoholic drinks and carbonated beverages
12. Food additives and
13. Spices and condiments

### **Packaging of milk products:**

**1. *Pasteurized flavoured milk:*** It should be filled in glass bottles and capped. LDPE lined cartons/aseptic cartons or any other suitable containers have also been recommended.

**2. *Sterilized flavoured milk:*** It should be filled in glass bottles or sanitary cans, properly sterilized. Polypapers or poly-laminated paper packs in tetrahedron, pyramid or other forms may also be used. The containers should be capped or sealed air-tight and placed in a sterilizer where they should be gradually heated to a suitable temperature and cooled to room temperature.

**3. *Sterilized milk:*** It should be packed in glass bottles or sanitary cans properly sterilized and stocked in such a way as to protect it from contamination. Polypapers or poly laminated paper packs in tetrahedron, pyramid or other forms may also be used.

**4. *Condensed milk/Sterilized cream:*** These products should be packed in hermetically sealed containers or LDPE lined cartons/aseptic cartons. In case of condensed milk, the side seam of the container may be soldered or cemented. The type of cement used should not impart any odd flavour to the milk and should also be non toxic.

**5. *Fermented milk products and Dahi:*** They should be filled in glass bottles or any other suitable container and capped. They should not be exposed to warmer temperature as the products become too sour due to growth of micro-organisms. The fermented milk products should be cooled before dispatch and maintained preferably at a temperature below 10°C, to develop good flavour and texture.

**6. *Canned Rasogolla:*** For canned rasogolla, the packaging materials suggested are open top sterilized sanitary cans or polystyrene tubs or any other suitable containers with as little air as possible.

**7. *Milk powder, Cereal weaning foods:*** For the above products, the code has recommended that these products should be packed in hermetically sealed and clean containers in such a way as to protect them from deterioration. These may also be packed in hermetically sealed tinplate containers in N<sub>2</sub> or a mixture of N<sub>2</sub> and CO<sub>2</sub> gas. Other packing material that may be considered is bag-in-box having inner layers made of PET/LDPE which can be gas flushed. Infant milk food and whole milk powder when manufactured by the spray drying process should be packed in N<sub>2</sub> or a mixture of N<sub>2</sub> and CO<sub>2</sub> gas.

## Lecture No. 10

*Packaging of fruits and vegetables – Meat, fish and poultry – Bakery and confectionary products – Protein rich foods*

### **Packaging of fruits and vegetables:**

**1.Raw vegetables and fruits:** Raw vegetables may be packed loose in bulk or packed in containers for trading and transport. In the latter case, the vegetables should be packed in new loosely woven gunny bags or wooden/plastic crates or in lined or unlined corrugated fiberboard boxes.

**2.Onion and garlic:** These should be packed in sound, clean, new loosely woven gunny bags, net bags, bamboo baskets or palm leaf baskets or wooden crates or lined or unlined corrugated fiberboard boxes or in any other suitable manner so as to allow proper aeration of the bulbs.

**3.Tomatoes:** Tomatoes should be packed in baskets or wooden boxes or lined or unlined corrugated fiberboard boxes. While packing, it should be ensured that the tomatoes are not unduly pressed when the lid is closed.

**4.Chillies:** Fresh chillies should be packed in gunny bags or in bamboo baskets, or in corrugated boxes, lined or unlined. The containers should be so constructed as to allow for proper aeration of the packed material.

**5. Guava, Lime and mandarin:** They should be packed in wooden boxes or lined or unlined corrugated fiberboard boxes. The boxes should be made in such a manner as to allow for proper aeration of the fruits. Sufficient quantity of straw should be put in the container to prevent fruits from rubbing against each other. Super grade fruit should be wrapped individually either in tissue paper or in any other suitable material before being packed into the container.

**6. Juices, jams, jellies and marmalades:** They should be packed in glass bottles or open top cans. Tomato juice be packed in glass or tinsplate containers and hermetically sealed. The containers may be either plain or lacquered; if lacquered, the lacquer should be of the acid resistant type.

### **Packaging of Meat, fish and poultry products:**

**1.Meat:** Meat should be wrapped in polyethylene sheets or bags and delivered in clean, rust free and closed containers. If the time involved in packaging and transport is more than 2 hours, the meat should be covered with ice.

If the meat has to be supplied to the distant market, meat should be wrapped in polyethylene sheets and packed in clean, rust free and closed containers which

are sufficiently strong to withstand repeated handling. The containers should have an outlet for drinking of water resulting from melting of ice used to chill the meat. When the meat is chilled by using CO<sub>2</sub> or any other more effective chilling medium, the time involved for reaching the destination may be upto 1 hours. This type of packing with ice should be used when the distance involved can be covered in 6 hours from the time of packing to the time of delivery.

**2.Cooked meat product:** They should be packed in butter paper or any grease proof clean wrapping material. All the sliced cooked meat products shall be wrapped in butter paper and then put in big polyethylene cover. Finally, the polyethylene container should be packed in clean, rust free and closed containers sufficiently strong to prevent any damage to the meat products packed.

Alternatively, the meat including whole carcasses and cooked meat products may also be vacuum packed using suitable wrapping materials such as PET/ LDPE.

**3.Dressed chicken:** The drained and dressed birds should be packed into suitable sized polyethylene bags or other suitable packing material. Before final sealing, the packs should be immersed into vats containing water to expel the content of air between the carcass and the bag, taking care that no water is introduced in the pack. Alternatively, vacuum packing or shrink wrapping of the packs may be adopted. After the air inside is expelled, the bag should be sealed on a sealer or should be knotted using rubber bands.

**4.Egg powder:** Egg powder should be gas packed in nitrogen in suitable tinsplate containers or flexible packaging materials. PET/LDPE laminate may be considered for the purpose.

**5. Fish:** The fresh product should be packed in polyethylene lined insulated containers, made of plywood, country wood or plastic. The thickness of insulation may vary from 15 to 30 mm depending upon the storage period and the mode of transport. Thermocole or fiberglass may be used as insulation material. Adequate drainage of melted ice may be provided.

#### **Bakery and confectionary products:**

**1.Bread:** The packaging for bread should be such that it should be wrapped in slice form in LDPE coated poster paper or clean waxed paper, grease –proof paper or any other suitable non-toxic wrapper. The loaf may be packed either in sliced form or as it is.

**2.Biscuits:** The material for packing should be clean, sound containers made of tinsplate, cardboard paper or other suitable material such as cello/LDPE, BOPP/LDPE, PET/LDPE and also paper/LDPE, foil/LDPE in such a way as to protect them from breakage, contamination, absorption or moisture and seepage of fat from

the biscuits into the packing materials. The biscuits should not come in direct contact with the packing material other than grease-proof or sulphate paper, cellulose film, aluminium foil laminate. The biscuits in tins should not come in direct contact with the metal walls.

**3.Cakes:** The cakes should be wrapped or packed in clean waxed paper, grease-proof polyethylene, glassine/LDPE or any other suitable wrapper or tins. The cakes should be thoroughly cooled in clean atmosphere before packing.

**Protein-Rich foods:**

**1.Protein-Rich extruded foods:** The packaging material should be moisture-proof, clean and sound. These foods may be packed in moisture proof paper bags (multi-layered, polyethylene lined) or pouches made from BOPP/LDPE, glassine/LDPE or high density polyethylene woven bags having 300 gauge LDPE liner for bulk (i.e. 10, 15, 20 and 25 kg) or in suitable moisture proof multi-service containers. Small quantities (i.e. 20 to 250 g) for consumer market may be packed in 250 gauge HDPE bags in such a way to protect it from deterioration.

**2.Peanut butter:** It should be packed in wide-mouthed glass jars or polystyrene tubs or any other suitable container of the required size and shape. The container should have an air-tight seal in order to avoid oxidative rancidity and to preserve freshness.



## Lecture No. 11

*Packaging of Edible starches and starch products – Oils and Fats – Food grains and food grain products – Sugar and Honey - stimulant foods – Alcoholic drinks and carbonated beverages –Spices and Condiments*

### **Packaging of edible starches and starch products:**

**1.Flours and starches:** The material should be packed in either LDPE coated jute bags or LDPE coated raffia bags. The mouth of each bag should be either machine-stitched or rolled over and hand stitched, in a suitable manner.

**2.Edible spray dried potato flour:** The edible spray dried potato flour should be packed in clean, sound and dry tinplate containers. These should be packed in flexible materials made of HDPE or metallized polyester bags or pouches made from other flexible laminates such as BOPP/LDPE. The flexible material used should have high barrier properties against oxygen and moisture.

### **Oils and fats:**

**1.Oil:** The oil should be packed in suitable well closed containers. The packaging material used may be tinplate containers, glass bottles, rigid plastic containers of HDPE, food grade PVC, PET and flexible pouches made of plastic film/foil/laminate. Flexible pouches of biaxially oriented nylon (BON) film/ionomer and coextruded nylon/ionomer may be considered.

**2.Fat, Vanaspati:** The material should be packed in suitable sealed packages, such as, flexible packs and well closed tinplate containers. The net mass of oils, fats and vanaspati to be packed should be 500 g, 1 kg, s kg, 5 kg and thereafter in multiples of 5 kg.

### **Food grains and food grain products:**

**1.Cereal grains:** Cereal gains should be packed in new, clean jute bags or LDPE coated jute bags and raffia bags. The mouth of each bag should be machined stitched.

**2.Cereal flours:** The cereal flours should be packed in 1, 2, 10, 20, 40, 65, 75, or 90 kg bags. For packages above 65 kg, the material for packaging should be either LDPE coated jute bag/LDPE coated raffia bags or single sound A-twill or B-twill jute bags. The bags used for smaller packs may be polyethylene bags or polyethylene lined jute bags.

The mouth of the bag should be either machine stitched or hand stitched. If it is hand stitched, the mouth should be rolled over and then stitched. The stitches should be in tow rows with atleast 14 stitches in each row for jute bags of 65 kg and above.

### **Sugar and honey:**

**1.Sugar:** It should be packed in either polyethylene coated Hessian bags or polyethylene coated raffia bags or in clean, sound and new A-twill jute bags. The bags may be lined with polyethylene film. The mouth of each bag should be either machine stitched or rolled over and hand stitched. The stitches should be in two rows with at least 14 stitches in each row if it is hand stitched.

**2.Cube sugar:** The number of cubes corresponding to a net weight of 0.5 kg should be wrapped together in butter paper or kraft paper and packed in cartons. Alternatively, these may also be packed in LDPE coated poster paper.

**3.Honey:** The packing of honey should be in hygienically clean and wide mouthed glass containers or in acid resistant lacquered tinplate containers or in suitable polyethylene containers. The screwed caps of glass containers should be of non-corrosive and non-reactive material and should be provided with cork washers to avoid spilling.

### **Packaging of Stimulant foods:**

**1.Tea:** To maintain the flavour of tea, it should be packed in such a manner as to allow the tea to retain its freshness. Tea could be packed in flexible packaging materials or laminates such as LDPE, paper coated LDPE, PET/LDPE and BOPP/LDPE.

**2.Roasted and ground coffee:** The product should be packed in clean, sound packing materials such as tinplate, glass containers, metal foil, plastic films or in laminated pouches of paper/LDPE, PET/LDPE and BOPP/LDPE. The product may also be vacuum packed or packed in inert gas.

**3.Chocolates:** Chocolates meant for covering purposes should be packed in clean, sound and odour-free containers. Such containers may be either made of tinplate, plastic, grease-proof paper, aluminium foil or laminates made of paper/LDPE, BOPP/LDPE.

In case of other types of chocolates, each unit of chocolate should be wrapped in aluminium foil, printed or otherwise and may be lined with glassine or grease-proof paper. Such units may be over wrapped by a decorative band. These units in turn, should be collectively packed in clean and odour-free cardboard cartons. Such cartons should be finally over wrapped with bituminized kraft paper with all joints well-sealed to ensure the prevention of entry of moisture and dust.

### **Alcoholic drinks and carbonated beverages:**

**1.Carbonated beverages:** Carbonated beverages should be filled in glass containers conforming to IS 1107:1986 or in PET bottles. It may also be filled in cans, plastic containers and dispensing units. The containers should be filled under strict

hygienic conditions. After filling, the containers should be hermetically sealed with clean, new crown corks conforming to IS 1994:1987.

**2.Beer:** Beer may be filled in 650 ml glass bottles or in PET bottles. The bottles should be properly sealed with gas-tight crown caps. Beer may also be packed in cans. Bottles or cans should be packed in wooden cases or corrugated fiber board boxes.

**Spices and condiments:**

**1.Chillies:** Chillies should be packed in clean and sound jute bags or in pouches made from PET/EVA or BOPP/EVA or in suitably lined wooden cases. The material may also be packed in LDPE coated raffia bags.

**2.Black pepper:** It should be packed in clean and sound jute bags with or without moisture-proof lining or LDPE coated raffia bags which do not impart any foreign smell to black pepper. The mouth of each bag should be either machine stitched or rolled over and hand stitched.

**3.Colves:** Whole and ground cloves should be packed in clean and sound air-tight containers, made of a material which does not affect the cloves. Packing in PET/LDPE bags may be considered.

## Lecture No. 12

*Packaging materials – Classification of packages – Paper as packaging material – Paper manufacture – pulp – Mechanical pulp – Chemical pulping – Alkaline process – Soda process- Sulfate process – sulphate process – semi chemical pulping – Digestion*

### **Packaging Materials:**

1. Paper based packaging materials
2. Metal packaging materials
3. Glass packaging materials
4. Plastic packaging materials
5. Edible and bio based packaging materials

### **Classification of Packages:**

Packages can be classified as 1) traditional or natural and 2) fabricated or modern packaging materials based on the availability of the materials.

Examples for traditional or natural packaging materials are – Bamboo basket, fiber or leaf mats, Leather containers of animal skin, clay containers, gunny bags, cloth bags, Arecanut and teak leaves sheath.

The modern packaging materials can be divided into rigid, semi rigid and flexible materials. Examples for rigid containers are – metal drums, metal barrels, glass bottles, glass jars, wooden boxes, wooden crates, plastic bottles, plastic drums, plastic crates, paper drums, plywood containers. Examples for semi rigid containers are – aluminium collapsible tube, plastic collapsible tube, composite container, paper based cartons. Example for flexible container is plastic bags.

### **Paper as Packaging Material:**

Paper derives its name from the reedy plant “**papyrus**”, which the ancient Egyptians used to produce the world's first writing material by beating and pressing together thin layers of the plant stem. The first authentic papermaking - the formation of a cohesive sheet from the rebonding of separated fibers - has been attributed to **Tsai-Lun** of China in 105 AD, who used bamboo, mulberry bark and rags.

Paper is widely used as a packaging material because of its stiffness and printability. The main advantages of paper as packaging material are – Good stiffness, good absorbent, good creaseability, good printability, low density, not brittle, biodegradable, low cost. The main disadvantages are – poor tensile strength, poor wet strength, tear easily, no barrier property without coating.

## ***Paper manufacturing:***

### ***Pulp:***

Pulp is the fibrous raw material for the production of paper, paperboard, corrugated board, and similar manufactured products. It is obtained from flax, bamboo and other grasses, various leaves, cottonseed hair, mulberry bark, rags and the woody fibers of trees. At present, about 97% of the world's paper and board is made from wood pulp.

There are three main constituents of the wood cell wall:

**1. Cellulose.** It is a long-chain linear polymer consisting of a large number of glucose molecules and is the most abundant, naturally occurring organic compound. The fiber forming properties of cellulose depend on the fact that it consists of long, relatively straight chains that tend to lie parallel to one another.

**2. Hemicelluloses.** These are lower molecular weight mixed-sugar polysaccharides. Hemicelluloses are largely responsible for hydration and development of bonding during beating of chemical pulps.

**3. Lignin.** This is the natural binding constituent of the cells of wood and plant stalks. It has no fiber forming properties, and is attacked by chlorine and sodium hydroxide with formation of soluble, dark brown derivatives. It softens at about 160°C.

### ***Introduction to pulping:***

The cell wall of softwoods, which are preferred for most pulp products, typically contain 40 to 44% cellulose, 25 to 29% hemicelluloses and 25 to 31% lignin by weight. Softwoods fibers are generally up to 2.5 times longer than hardwoods fibers. As a result, hardwoods produce a finer and smoother, but less strong, sheet.

The purpose of pulping is to separate the fibers without damaging them so that they can then be reformed into a paper sheet in the papermaking process. The intercellular substances (primarily lignin) must be softened or dissolved to free individual fibers. Breaking and weakening of the fibers does occur at various stages during the pulping process.

Pulps that retain most of the wood lignin consist of stiff fibers that do not produce strong papers. They deteriorate in colour and strength quite rapidly. These properties can be improved by removing most or all of the lignin by cooking the wood with solutions of various chemicals; the pulps thus produced are known as **chemical pulps**. In contrast, **mechanical pulps** are produced by pressing logs onto a grindstone when the heat generated by friction softens the lignin so that the fibers separate with very little damage. Mechanical pulps can also be formed by grinding wood chips between two rotating refiner plates.

***Mechanical pulps:***

Groundwood pulp is produced by forcing wood against a rapidly revolving grindstone. Practically all the wood fiber (both cellulose and lignin) is utilized. This contrasts with several chemical processes where the lignin is dissolved to varying degrees. As a result, the yield of chemical pulp is about one half that of the mechanical process. The fibers vary in length and composition because they are effectively torn from the pulpwood.

Groundwood pulp contains a considerable proportion (70 to 80%) of fiber bundles, broken fibers and fines in addition to the individual fibers. The fibers are essentially wood with the original cell-wall lignin intact. Therefore, they are very stiff and bulky, and do not collapse like the chemical pulp fibers.

Most ground wood pulp is used in the manufacture of newsprint and magazine paper because of its low cost and quick ink-absorbing properties (a consequence of the frayed and broken fibers). It is also used as board for folding and molded cartons, tissues and similar products. The paper has high bulk and excellent opacity, but relatively low mechanical strength.

Mechanical pulps can be bleached using oxidative (e.g., hydrogen peroxide and sodium hypochlorite) or reductive (e.g., sodium hydrosulfite) bleaching agents. The bleaching is conducted in a lignin-conserving manner called *brightening*, in which the chromophores are modified and little solubilization of the lignin occurs. Paper and paperboard containing mechanical pulps have poor brightness stability, even after bleaching, particularly in the presence of UV radiation.

In the 1950s the refiner mechanical pulping (RMP) process was developed, which produced a stronger pulp and utilized various supplies of wood chips, sawmill residues and sawdust. However, the energy requirements of RMP are higher, and the pulp does not have the opacity of groundwood fibers.

***Chemical pulps:***

There are several chemical pulping methods, each of which are based, either directly or indirectly, on the use of sodium hydroxide. The objective is to degrade and dissolve away the lignin from middle lamella to allow the fibers to separate with little, if any, mechanical action. For production of chemical pulps, the bark is removed and the logs passed through a chipper. The chipped wood is charged into a digester with the cooking chemicals, and the digestion carried out under pressure at the required temperature.

**Alkaline Processes:****a) Soda process:**

The soda process consisted of boiling wood in 4 to 6% (by weight) sodium hydroxide liquor at a high temperature (170°C). Less than 2% of the pulp currently produced uses this process, which is very similar to the sulfate process, except that only sodium hydroxide is used.

**b) Sulfate (Kraft) Process:**

It is a modification of the soda process. Instead of sodium hydroxide, sodium sulfate was the major chemical used as the cooking liquor. The new sulfate process produced a much stronger pulp, which is more commonly known as kraft pulp after the German and Swedish for strength.

Today, the sulfate process is the dominant chemical wood pulping process and uses solutions of sodium hydroxide and sodium sulfide ( $\text{Na}_2\text{S}$ ) for cooking the chips. Pulp produced by this process is stronger than that produced from the same wood by the acid sulfite process, and the use of sulfate pulps in liner board has enabled the replacement of wooden cases by corrugated cartons. The sulfate and acid sulfite processes together account for over 90% of the chemical wood pulp currently produced in the world.

**2. Sulfite Processes:**

Several pulping processes are based on the use of sulfur dioxide as the essential component of the pulping liquor. Sulfur dioxide dissolves in water to form sulfurous acid, and a part of the acid is neutralized by a base in preparation of the pulping liquor.

**Semi chemical pulps:**

Semichemical pulping combines chemical and mechanical methods in which wood chips are partially softened or digested with conventional chemicals, such as sodium hydroxide, sodium carbonate or sodium sulfate, after which the remainder of the pulping action is supplied mechanically, most often in disc refiners.

The object of this process is to produce as high a yield as possible to obtain the best possible strength and cleanliness. The hemicelluloses, mostly lost in conventional chemical digestion processes, are retained to a greater degree in semichemical pulping and result in an improvement in potential strength development. Although less flexible, semichemical pulps resemble chemical pulps more than mechanical pulps.

***Digestion:***

The digestion process essentially consists of the treatment of wood in chip form in a pressurized vessel under controlled conditions of time, liquor concentration and pressure/temperature.

The main objectives of digestion are:

1. To produce a well-cooked pulp, free from the noncellulosic portions of the wood (i.e., lignin and to a certain extent hemicelluloses),
2. To achieve a maximum yield of raw material (i.e., pulp from wood) commensurate with pulp quality,
3. To ensure a constant supply of pulp of the correct quality.

Most pulping processes are continuous. After steaming at low pressure, during which time turpentine and gases are vented to the condenser, the chips are brought to the digester pressure of 1000 kPa in Kamyr continuous digester. They are picked up in a stream of pulping solution and their temperature is raised to 170°C over 1.5 h. After holding at this temperature for a further 1.5 h, the digestion process is essentially complete.

After digestion, the liquor containing the soluble residue from the cook is washed out of the pulp, which is then screened to remove knots and fiber bundles that have not fully disintegrated. The pulp is then sent to the bleach plant or paper mill.



## Lecture No. 13

*Bleaching - Beating and Refining - Paper making - Converting - Calendering - Strength additives - Sizing agents*

### **Bleaching:**

Pulps vary considerably in their color after pulping, depending on the wood species, method of processing and extraneous components. The whiteness of pulp is measured by its ability to reflect monochromatic light in comparison with a known standard (usually magnesium oxide). Brightness is an index of whiteness, measured as the reflectivity of a paper sample using light at 457 nm. Unbleached pulps exhibit a range of brightness values from 15 to 60. Cellulose and hemicellulose are inherently white and do not contribute to color; it is the chromophoric groups on the lignin that are largely responsible for the color of the pulp.

As bleaching reduces the strength of the pulp, it is necessary to reach a compromise between the brightness of the finished sheet and its tensile properties.

#### **1. Mechanical Pulps:**

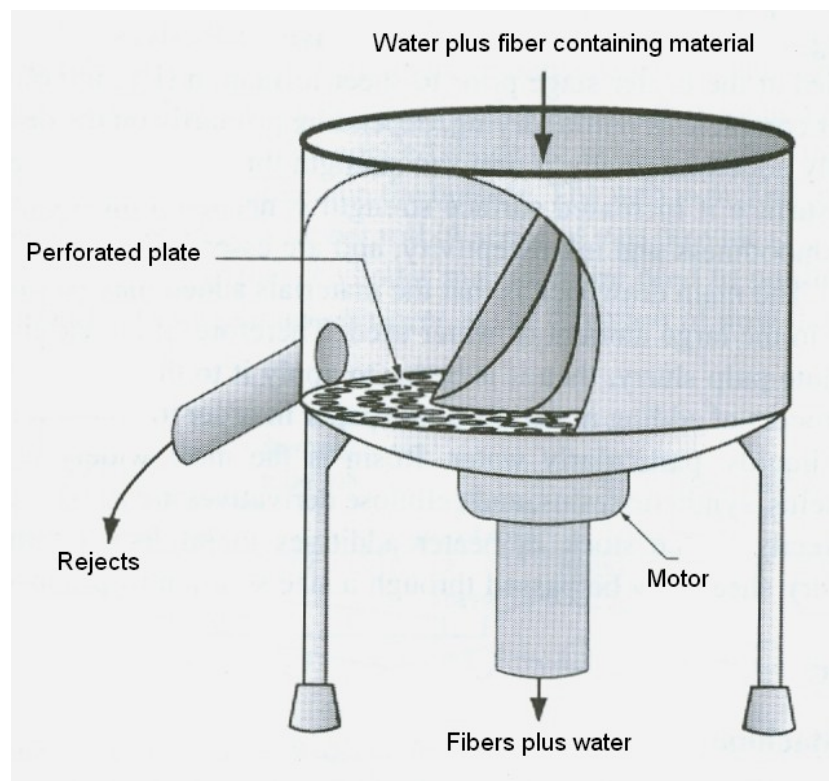
The most effective bleaching agent for most ground woods is hydrogen peroxide, and since the bleaching is performed in alkaline solutions, sodium peroxide is also used. The reaction requires 3 h at 40°C and is followed by neutralization and destruction of excess peroxide with SO<sub>2</sub>.

#### **2. Chemical pulps:**

Bleaching of chemical pulps is basically stepwise purification of colloidal cellulose, and bleaching can therefore be regarded as a continuation of the cooking process. The bleaching is performed in a number of stages utilizing one or more of the following: chlorine dioxide, oxygen, ozone, and peroxide. Between these stages, the pulp is treated with an alkali to dissolve degradation products.

### **PAPER:**

In the papermaking process, utilizing purchased pulps and waste paper, which are received as dry sheets, the first step is the separation of all the fibers from one another, and their dispersion in water with a minimum of mechanical work to avoid altering the fiber properties. This process is known as *slushing* or *repulping*, and is carried out in a machine such as the hydropulper (Figure 2), thus named because of the hydraulic forces that are developed.



**Figure 2. Hydrapulper**

***Beating and refining:***

Stock - as fibrous material is commonly called - is prepared through two main processes commonly referred to as beating and refining. Both operations are fundamentally the same. Beating and refining are used to improve the strength and other physical properties of the finished sheet.

The object of beating is to increase the surface area of the fibers by assisting them to imbibe water. The beating makes the fibers more flexible, causing them to become relatively mobile and to deform plastically on the paper machine. The mixture of pulp (known as the furnish) is passed into the beater and brought to a consistency of 5 to 7%. The fibers are then beaten while suspended in the water.

The quality and characteristics of the finished paper largely depend on the treatment in the beater. A sheet formed from an unbeaten pulp has a low density, and is rather soft and weak, whereas if the same pulp is beaten, then the resultant paper is much more dense, hard, and strong.

The batch-operated Hollander beater consists of a cylindrical roll containing knives that revolves over a stationary bedplate, which also contains a set of knives. Circulating stock passes between the roll and the bedplate; the severity of beating is controlled by adjusting the load of one against the other. Circulation is continued until

the pulp is considered ready to be made into the desired paper. In many papermills, beaters have been replaced by continuous refiners, including disc refiners (where rotary discs rotate against a working surface) and conical refiners.

In papermaking, chemicals such as strength additives, adhesives, mineral fillers, and sizing agents may be added at the beater stage prior to sheet formation (i.e., internal addition), or to the resulting sheet after complete or partial drying, depending primarily on the desired effects. Strength additives are usually added internally if uniform strength throughout the sheet is desired, but they are applied to the surface if increased surface strength is needed. Fillers can improve brightness, opacity, softness, smoothness and ink receptivity.

Sizing is the process of adding materials to the paper in order to render the sheet more resistant to penetration by liquids, particularly water. **Rosin** is the most widely used sizing agent, but starches, glues, caseins, synthetic resins, and cellulose derivatives are also used.

### ***Papermaking:***

#### ***Fourdrinier Machine:***

The principle of operation of the modern paper machine differs little from that of the first Fourdrinier machine of 1804.

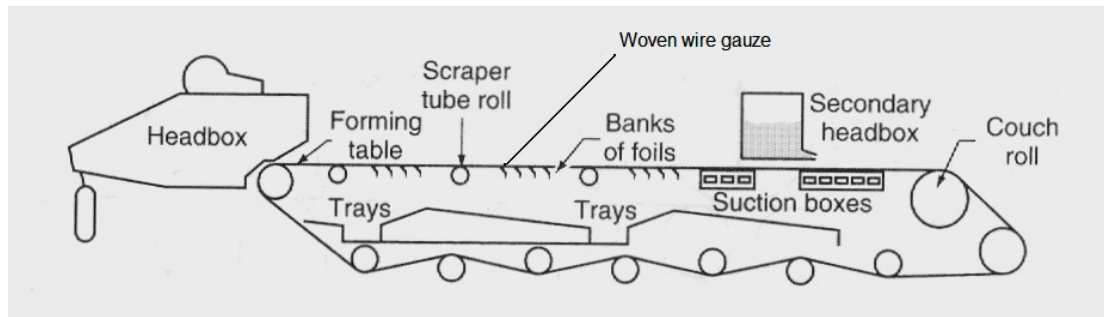
Paper is made by depositing a very dilute suspension of fibers from a very low consistency aqueous suspension (greater than 99% water) onto a relatively fine woven screen, over 95% of the water being removed by drainage through the wire. The fibers interlace in a generally random manner as they are deposited on the wire and become part of the filter medium.

Paper is usually subdivided into paper and paperboard. However, there is no rigid line of demarcation between the two, with structures <300µm being considered paper regardless of the grammage or weight per unit area. ISO standards define paperboard as paper with a basis weight (grammage) generally above 224 g per square meter.

The modern Fourdrinier paper machine (Figure 3) essentially consists of endless woven wire gauze or forming fabric stretched over rollers. The forming section of a Fourdrinier machine is made up of two essential parts: 1) The head box and 2) The drainage table.

The concentration of the fiber suspension delivered to the moving screen is generally 0.4 to 1.2%, and increases as a result of free drainage through the screen. The relative speeds of the stock and wire affect the degree to which the fibers are aligned along the direction of travel. The concentration increases to between 3 and 4% further down the Fourdrinier table where a vacuum is applied in the suction

boxes. For the production of multi-ply paperboard, a secondary head box is often used. Fourdrinier machines are used to produce all grades of paper and paperboard throughout the industry.



**Figure 3. Fourdrinier machine**

### ***Presses and Dryers:***

After leaving the forming fabric of the papermaking machine, the sheet (which has a moisture content of 75 to 90) passes to the press and dryer sections for further water removal. Rotary presses (which may have solid or perforated rollers, often with internal suction) receive the sheets on continuous felts, which act as conveyers and porous receptors of water. On leaving the press, the moisture content is typically 60 to 70%, again depending on type.

The paper is then passed through a series of steam-heated rollers and dried to a final moisture content of between 4 and 10%.

### ***Converting:***

The paper is converted by undergoing further treatment after manufacture, such as embossing, impregnating, saturating, laminating and the forming of special shapes and sizes such as bags and boxes. Further surface treatment involving the application of adhesives, functional products and pigments are common, depending on the end use of the paper.

#### ***1. Calendering:***

Calendering, a process that reorients the surface fibers in the base sheet of paper (or the coating applied to the surface) through the use of pressure. This serves to smooth the surface, control surface texture and develop a glossy finish. Such papers are known as *machine finished* (MF).

Supercalendering, as well as smoothing the surface of the sheet by pressure, also alters the optical reflectance of the sheet by friction, giving a higher finish than that obtained on calenders. As the paper passes between steel or fiber rollers under

great pressure, moisture is added. Only the bottom roller is powered; the others provide a certain amount of slippage, which irons the sheet.

## **2. Sizing:**

Surface treatments such as sizing and coating are extensively applied to improve the appearance of products. The most common method for the application of chemicals to the surface of a paper web is with a size press, where dry paper is passed through a flooded nip and a solution or dispersion of the functional chemical contacts both sides of the paper. Excess liquid is then squeezed out in the press and the paper is redried.

Surface-sizing agents prevent excess water penetration and improve the strength of the paper. The most commonly used materials for surface sizing are starches, usually chemically modified (e.g., oxidized starches, cationic starches and hydroxy-ethylated derivatives). Other film-forming materials that can be used for surface sizing include carboxymethyl cellulose (CMC) and polyvinyl chloride (PVC), which provide oil and grease repellent coatings and improve paper strength. Fluorochemical emulsion sizing agents can be applied to the surface of paper or paperboard to provide good oil and grease repellency. They find application for pet food bag papers, meat, fish and poultry wrap, cookie bags, and candy wrappers.

## **3. Adhesives:**

The primary function of the adhesive in pigment coating is to bind the pigment particles together and to the raw stock. The type and proportion of the adhesive controls many of the characteristics of the finished paper, such as surface strength, gloss, brightness, opacity, smoothness, ink receptivity, and firmness of the surface. Starches are used in many coated papers. Acrylicbased emulsions are used mostly on paperboard, and their odor-free quality makes them ideally suited for use in food packaging.

## **4. Barrier Coating:**

In many packaging applications, a barrier may be needed against water vapor or gases such as oxygen. A water barrier can be formed by changing the wettability of the paper surface with sizing agents. Coating the paper with a continuous film of a suitable material will confer gas or vapor barrier properties. Paraffin wax applied in a molten form was commonly used to produce a water vapor barrier, but polyethylene applied by extrusion gives a more durable and flexible coating.

## **5. Pigments:**

Pigments change the appearance of the base stock, improve opacity, impart a smooth and receptive surface for printing or provide special properties for particular purposes.

## Lecture No. 14

*Types of paper - Kraft paper - Bleached paper - Grease proof paper - Glassine paper - Vegetable parchment Waxed paper*

### **Types of Paper:**

Paper is divided into two broad categories:

(1) fine papers, generally made of bleached pulp, and typically used for writing paper, bond, ledger, book, and cover papers, and

(2) coarse papers, generally made of unbleached kraft softwood pulps and used for packaging.

### **Kraft paper:**

Kraft paper is typically coarse with exceptional strength, often made on a Fourdrinier machine and then either machine-glazed on a Yankee dryer or machine-finished on a calender. It is sometimes made with no calendering so that when it is converted into bags, the rough surface will prevent them from sliding over one another when stacked on pallets.

### **Bleached paper:**

Bleached paper is manufactured from pulps that are relatively white, bright and soft. It is more expensive and weaker than unbleached paper. Its aesthetic appeal is frequently augmented by clay coating on one or both sides.

### **Greaseproof Paper:**

Greaseproof paper is a translucent machine-finished paper that has been hydrated to give oil and grease resistance. Prolonged beating or mechanical refining is used to fibrillate and break the cellulose fibers, which absorb so much water that they become superficially gelatinized and sticky. This physical phenomenon is called hydration, and results in consolidation of the web in the paper machine with many of the interstitial spaces filled in.

The satisfactory performance of greaseproof papers depends on the extent to which the pores have been closed. They are often used for packaging butter and similar fatty foods since they resist the penetration of fat for a reasonable period.

### **Glassine paper:**

Glassine paper derives its name from its glassy, smooth surface, high density, and transparency. It is produced by further treating greaseproof paper in a supercalender where it is carefully dampened with water and run through a battery of steam-heated rollers. This results in such intimate interfiber hydrogen bonding that the refractive index of the glassine paper approaches the 1.02 value of amorphous

cellulose, indicating that very few pores or other fiber/air interfaces exist for scattering light or allowing liquid penetration. The transparency can vary widely depending on the degree of hydration of the pulp. The addition of titanium dioxide makes the paper opaque, and it is frequently plasticized to increase its toughness.

***Vegetable parchment:***

The process for producing parchment paper involves passing a web of high quality, unsized chemical pulp through a bath of concentrated sulfuric acid. The cellulosic fibers swell and partially dissolve, filling the interstices between the fibers and resulting in extensive hydrogen bonding. It is stronger wet than dry, free of lint, odor and taste, and resistant to grease and oils.

Because of its grease resistance and wet strength, it strips away easily from food material without defibering, thus finding use as an interleaver between slices of food such as meat or pastry. Labels and inserts in products with high oil or grease content are frequently made from parchment. It is used to wrap foods such as cheese.

***Waxed paper:***

Waxed papers provide a barrier against penetration of liquids and vapors. The major types are wet-waxed, dry-waxed, and wax-laminated.

Wet-waxed papers have a continuous surface film on one or both sides, which is achieved by shock-chilling the waxed web immediately after application of the wax. This also imparts a high degree of gloss on the coated surface. Dry-waxed papers are produced using heated rollers and do not have a continuous film on the surfaces. Consequently, exposed fibers act as wicks and transport moisture into the paper. Wax-laminated papers are bonded with a continuous film of wax that acts as an adhesive.

## Lecture No. 15

*Paper Boards - Paper board grades - Folding Cartons - Kinds of carton boxes - Beverage Cartons - Molded Pulp containers - Printing and varnishing - Die cutting and creasing - Gluing and sealing*

### **Paperboard Products:**

Paper is generally termed board when its grammage exceeds  $224 \text{ g m}^{-2}$ . Multi-ply boards are produced by the consolidation of one or more web plies into a single sheet of paperboard, which is then subsequently used to manufacture rigid boxes, folding cartons, beverage cartons and similar products. One advantage of multi-ply forming is the ability to utilize inexpensive and bulky low-grade waste materials (mostly old newspapers and other postconsumer waste papers) in the inner plies of the board where low fiber strength and the presence of extraneous materials (e.g., inks, coatings, etc.) have little effect on board properties. However, multi-ply boards containing postconsumer waste papers are not used for food contact purposes.

### **Paperboard Grades:**

**Linerboard:** Board having at least two plies, the top layer being of relatively better quality; usually made on a Fourdrinier with 100% virgin pulp furnish.

**Foodboard:** Board used for food packaging having a single- or multi-ply construction, usually made from 100% bleached virgin pulp furnish.

**Folding Boxboard (Cartonboard):** Multi-ply board used to make folding boxes; top ply (liner) is made from virgin pulp, and the other plies are made from secondary fiber.

**Chipboard:** Multi-ply board made from 100% low-grade secondary fiber.

**Base Board:** Board that will ultimately be coated or covered.

### **Folding Cartons:**

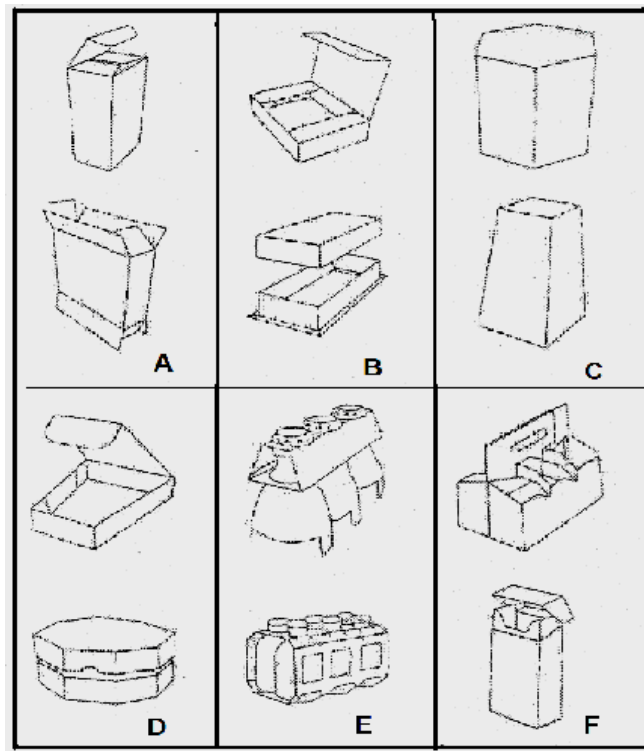
Folding cartons are containers made from sheets of paperboard (typically with thicknesses between 300 and 1100  $\mu\text{m}$ ), which have been cut and scored for bending into desired shapes.

**Kinds of Folding Carton Boxes:** The carton boxes are grouped into 6 and are shown in Figure 4.

- 1) Group A – Long seam glued folding cartons with rectangular surfaces
- 2) Group B – Folding cartons with rectangular surfaces, non long seam glued
- 3) Group C – Long seam glued folding cartons with non rectangular surfaces



- 4) Group D – Folding cartons with non rectangular surfaces non long seam glued
- 5) Group E – Product integrated folding carton
- 6) Group F – Other folding cartons



**Figure 4. Different kinds of folding carton boxes**

#### ***Beverage Cartons:***

The carton normally consists of layers of bleached and unbleached paperboard coated internally and externally with LDPE, resulting in a carton that is impermeable to liquids and in which the internal and external surfaces may be heat sealed. There may also be a thin layer of aluminum foil, which acts as a gas and light barrier. Incorporation of an aluminum foil layer allows a longer shelf life for chilled premium juice products

#### ***Molded pulp containers:***

The term "molded pulp" is used to describe 3D packaging and food-service articles that are manufactured from aqueous slurry of cellulosic fibers.

The forming process is similar to the paper-making process, except that a mold fitted with a screen is used in place of the moving wire screen. Two molding processes are used. First, a pressure injection process in which air under pressure and at a temperature of approximately 480°C is used to form a pulp and water mixture in a mold. Second, a suction molding process is used where a partial vacuum

is applied to one side of the mold screen after the pulp mixture has been placed in the mold.

Well-known forms of molded pulp articles made by the suction-molding process include egg cartons, food trays and many other forms of tray-shaped articles for packing fruit and other commodities.

***Printing and Varnishing:***

In the printing and varnishing process, the plain board sheets are printed with the artwork made up by the art specialists in upto 7 different colours and are in most cases varnished afterwards to protect the colours. The most widely used printing method is offset printing as it offers high print quality and low plate costs.

***Die cutting and creasing:***

In the conversion of paper board, the die cutting and creasing operations are usually performed simultaneously in a die cutting station, which can be offline or in line with the printing press. Die cutting and creasing are frequently combined with embossing.

***Gluing and sealing:***

The gluing and sealing of a carton is the last link in a long chain of operations for converting paperboard into a functional and attractive package. Side seam gluing means applying glue to a side flap, pressing it to a side panel and maintaining the pressure until the glue seam has set. The glue must not affect the packed product.

## Lecture No. 16

*Glass as Package material - Composition of Glass - Parts of Glass container - Closures - Parts of Closures - Types of Closures - Properties of glass - Internal pressure resistance - Vertical load Strength- Resistance to impact - Resistance to Scratches and Abrasions*

### **Introduction:**

Glass has been defined by the American Society for Testing and Materials (ASTM) as "an amorphous, inorganic product of fusion that has been cooled to a rigid condition without crystallizing".

The two main types of glass container used in food packaging are bottles (which have narrow necks) and jars (which have wide openings). About 75% of all glass food containers in the U.S. are bottles and approximately 85% of container glass is clear, the remainder being mainly amber.

### **Composition and structure:**

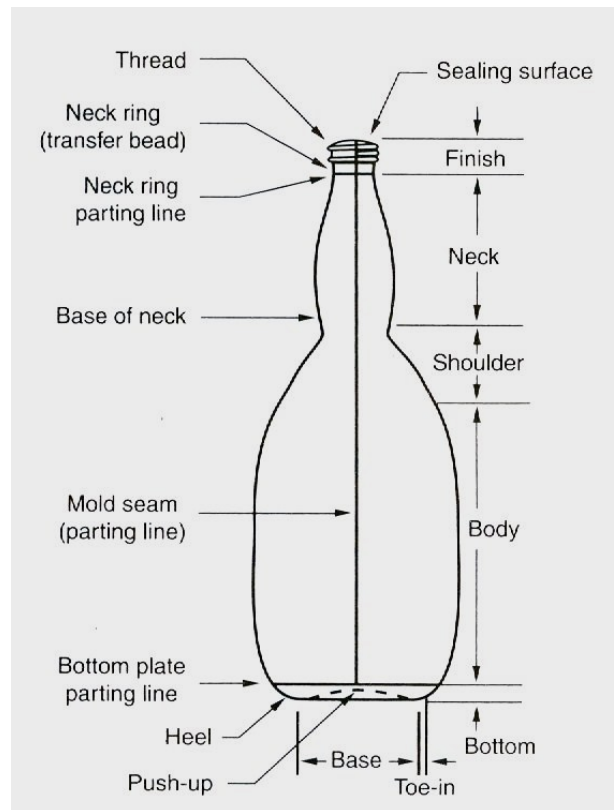
The basic raw materials for glassmaking come from mines or quarries and must be smelted or chemically reduced to their oxides at temperatures exceeding 1500°C. The principal ingredient of glass is silica derived from sand, flint or quartz. Silica can be melted at very high temperatures (1723°C) to form fused silica glass which, because it has a very high melting point, is used for specialized applications including some laboratory glass. As a consequence of the sodium in glass being loosely combined in the silica matrix, the glass surface is subject to three forms of "corrosion": etching, leaching and weathering.

Etching is characterized by alkaline attack, which slowly destroys the silica network, releasing other glass components. Leaching is characterized by acid attack in which hydrogen ions exchange for alkali or other positively charged mobile ions. The remaining glass (principally silica) usually retains its normal integrity. A mild form of weathering is commonly known as surface bloom and may occur under extended storage conditions.

Glass is neither a solid nor a liquid but exists in a vitreous or glassy state. Although glass has many of the properties of a solid, it is really a highly viscous liquid. Evidence for this can be obtained by examining very old window panes that are slightly thicker at the bottom than at the top. The basic structural unit is the silicon-oxygen tetrahedron in which a silicon atom is tetrahedrally coordinated to four surrounding oxygen atoms.

### **Parts of Glass container:**

The basic nomenclature used for glass containers is shown in Figure 5.



**Figure 5. Glass container nomenclature**

The three basic parts of a glass container are the finish, the body and the bottom. These are formed by the three parts of the glass container molds in which they are made. *Finish* is the part of the bottle that holds the cap or closure, the glass surrounding the opening in the container. *Body* of the container is the portion that is made in the body-mold. It is, in most cases the largest part of the container and lies between the finish and the bottom. *Bottom* of the container is made in the bottom plate part of the glass-container mold.

### **Closures:**

The closures consist of a cap, cork or plug to seal the jar or bottle. Closures are required to perform the some or all of the following functions.

1. Provide an effective hermetic (air-tight) seal to prevent the passage of solids, liquids or gases into or out of the container.
2. Provide easy opening and resealing of the container.

3. Provide evidence of inviolability (i.e. that unlawful access to the contents or their exposure to the atmosphere has not occurred). Roll on pilfer proof (ROPP) closures leave a tell tale ring around the bottom of the neck of bottles after opening.

**Closure terminology:**

*Panel* is the flat center area in the top of the closure.

*Radius* or *shoulder* is the rounded area at the outer edge of the panel connecting the panel and the skirt.

*Skirt* is the flat, almost vertical portion on the side of the closure, which serves as the gripping surface and may be smooth, knurled or fluted.

*Curl* is the round or rolled portion at the bottom of the skirt that adds rigidity to the cap and serves to protect the cut edge of the metal.

*Lug* is a horizontal inward protrusion from the curl that is seated under the thread on the glass finish and holds the cap in position.

*Thread* is the spiral groove on the skirt of a continuous thread closure that meshes with the tread on the glass finish.

*Face* is the outside of the cap.

*Reverse* is the inside of the cap.

*Gasket* or *liner* is the actual sealing component of the closure, which makes an intimate contact with the glass finish to form an effective seal. Gaskets are made from rubber or plastisols.

**Food container closures:**

Closures used with food containers can be classified under four headings. They are

1. Closures to retain internal pressure – They retain an internal pressure of 200-800 kPa, as found in carbonated drinks and beer. Ex. Crown cork, Roll-on tamper evident aluminum closure
2. Closures to contain and protect contents – They contain and protect the contents with no internal pressure (Ex. Wine in a bottle). Ex. Bark cork
3. Closures to maintain vacuum inside container – They maintain a vacuum inside glass containers that typically contain heat-processed food. Ex. Lug-type or twist cap, Press-on twist-off cap, Pry-off (side seal) cap
4. Closures to secure contents inside container – They are to secure the contents inside the glass container (Ex. Peanut butter)

## Properties of Glass:

### **a. Mechanical Properties**

Because of its amorphous structure, glass is brittle and usually breaks due to applied tensile strength.

$$\text{Tensile stress} + \text{Stress concentrator} = \text{Fracture}$$

The following four aspects are important in glass container breakage:

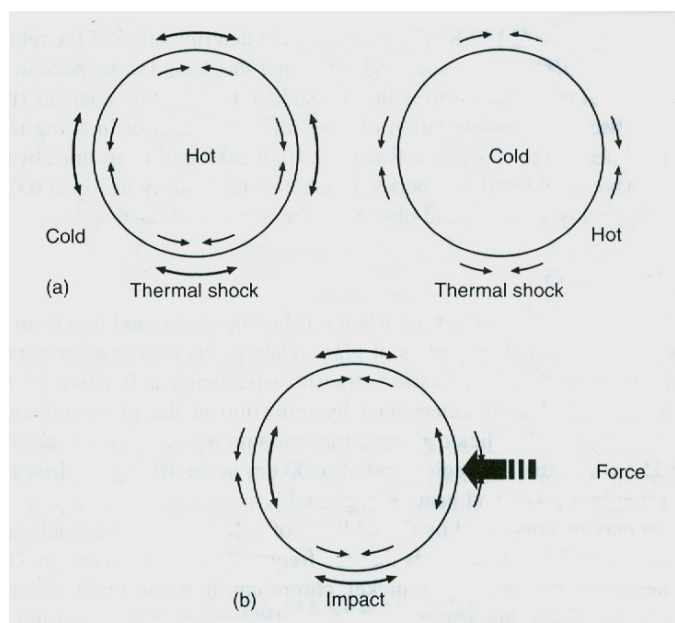
**1. Internal pressure resistance.** This is important for bottles produced for carbonated beverages, and when the glass container is likely to be processed in boiling water or in pressurized hot water. Internal pressure produces bending stresses at various points on the outer surface of the container are shown in Figure 6(a).

**2. Vertical load strength.** While glass can resist severe compression, the design of the shoulder is important in minimizing breakage during high-speed filling and sealing operations.

**3. Resistance to impact.** Two forms of impact are important - a moving container contacting a stationary object (as when a bottle is dropped), and a moving object contacting a stationary bottle (as in a filling line). In the latter situation, design features are incorporated into the sidewall to strengthen contact points. The development of surface treatments (including energy absorbing coatings) to lessen the fragility of glass when it contacts a stationary object has been very successful. A cross-section of a round bottle illustrating the ways in which tensile stresses on the inside and outside surfaces vary at various points around the bottle circumference is shown in Figure 6 (b).

**4. Resistance to scratches and abrasions.** The overall strength of glass can be significantly impaired by surface damage such as scratches and abrasions. This is especially important in the case of reduced wall thickness bottles such as "one-trip" bottles. Surface treatments involving tin compounds (in conjunction with other treatments) provide scuff resistance, thereby overcoming susceptibility to early failure during bottle life.

Although the mechanical strength of a bottle or jar can increase with glass weight, this is at the expense of thermal strength which decreases with increasing glass weight.



**Figure 6. Cross-section of a round glass container illustrating various stresses on the inside and outside surfaces**

### ***B. Thermal Properties:***

The thermal strength of a glass container is a measure of its ability to withstand sudden temperature change. Glass has the least resistance to temperature changes. The resistance to thermal failure depends on the type of glass employed, the shape of the container, and the wall thickness.

The temporary stresses from sudden cooling are much more damaging than those resulting from sudden heating, since the potentially damaged outside surface is in tension. The amount of tension produced in one surface of a bottle by suddenly chilling it is about twice as great as the tension produced by suddenly heating the other surface.

Resistance to breaking is determined by transferring glass containers which have been totally immersed in a hot water bath (typically at 63°C) for 5 min to cold water bath (typically at 21°C) and observing the number of breakages.

### ***C. Optical Properties:***

Glass is optically isotropic. The optical properties of glass relate to the degree of penetration of light and the subsequent effect of that transmission, transmission being a function of wavelength. Transmission may be controlled by the addition of coloring additives such as metallic oxides, sulfides or selenides, and the compounds that are frequently used.

## Lecture No. 17

*Glass manufacture - Press and Blow (P&B) - Narrow Neck Press and Blow (NNPB) - Shape of glass Container*

### **Glass Manufacture:**

#### **A. mixing and melting:**

The largest constituent (68 to 73%) is silica; the second largest constituent (15 to 50%) is cullet (i.e., scrap or recycled glass), originating as both glass scrap from the factory and recycled glass from consumers. Use of cullet is economically desirable since less energy is required to melt cullet than new raw materials. Cullet also reduces the amount of dust and other particulate matter.

The raw materials are weighed, mixed and charged into a glass-melting furnace, which is maintained at a temperature of approximately 1500°C. Here, they are converted into molten glass that is chemically homogeneous and virtually free of gaseous inclusions (bubbles). The melting process consists of two phases:

- (1) Changing the solids into a liquid, and
- (2) Fining or "clearing up" of the liquid.

During the refining process, gases (principally CO<sub>2</sub>, SO<sub>2</sub> and water vapor) produced by the chemical reaction rise to the surface of the furnace and are removed. When the molten glass becomes free of gas (seed-free), it is then ready for forming into containers. It moves from the furnace into the working end of the furnace (mistakenly called the refiner) where thermal homogenization and cooling of the glass to the viscosity required for the particular operation begin. At this point, the temperature of the melt has been lowered from 1250-1350°C to approximately 1100°C. The preferred energy source for glassmaking is natural gas, although alternate fuels such as oil and propane are used in some plants.

#### **B. Forming process:**

The glass is carried from the working end of the furnace to the forming machine in a channel-like structure called a *forehearth*, which is fired by a number of small burners, the aim being to ensure uniform temperature distribution throughout the depth of the glass. At the end of the forehearth is a gob-forming mechanism consisting of a rotating sleeve and vertical plunger. The glass exits in a continuous, viscous stream which is cut by rapidly moving, horizontal steel blades to form what known as a "gob" (i.e., a mass or lump of molten glass).



Precise control of temperature and shape during the formation of the gob is required for the high-speed production of accurately formed glass containers. Temperatures in the vicinity of 1100°C varying by no more than  $\pm 1^\circ\text{C}$  are typical.

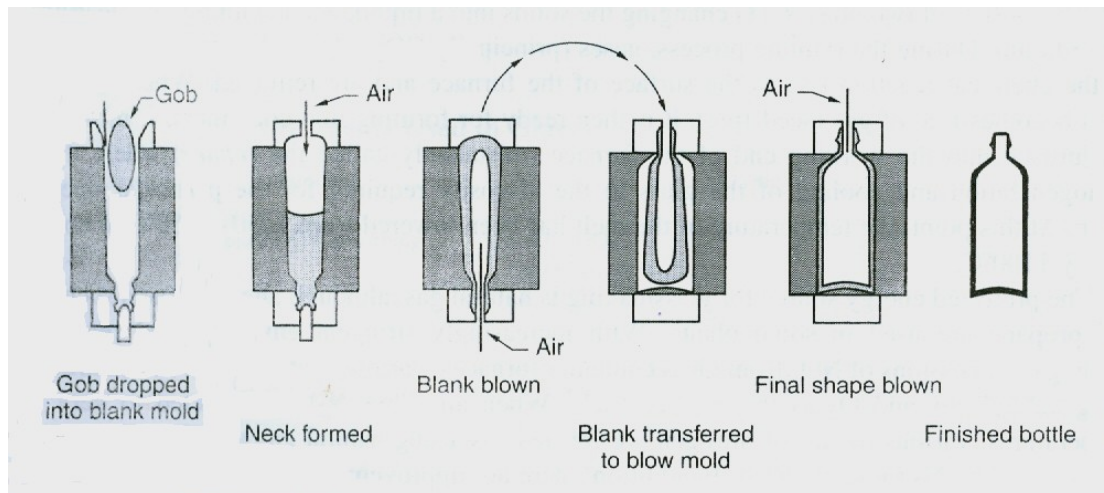
The process of converting a cylindrically shaped gob of glass into a bottle or jar is called forming, and it is essentially a controlled cooling process. While various types of forming machines are used throughout the world, the most predominant is the IS (individual section) machine. It consists of up to 16 sections, each one an individually functioning, hollow glass machine. It performs two basic functions: it shapes the gob into a hollow container, and simultaneously removes heat from the gob to prevent it from deforming significantly under its own weight.

Two basic types of processes are used to make containers on the IS machine: the blow and blow (B&B) and the press and blow (P&B). A closure size of approximately 35 mm is the dividing line between narrow-neck B&B containers (i.e., bottles) and wide-mouth P&B containers (i.e., jars).

#### **1. Blow and Blow (B&B):**

Bottles are normally produced by a two-step B&B process (Figure 7) whereby a gob of glass, accurately sheared in terms of weight and shape, is dropped into an externally air cooled, cast iron cavity to shape a preform (also known as a parison or body blank). Some of the glass flows over a plunger in the base of the mold, which is used to mold the finish of the container by means of ring molds. Compressed air is applied to force the glass down onto the plunger to form the neck ring. Sometimes, vacuum is applied from the bottom as an alternative or additional procedure.

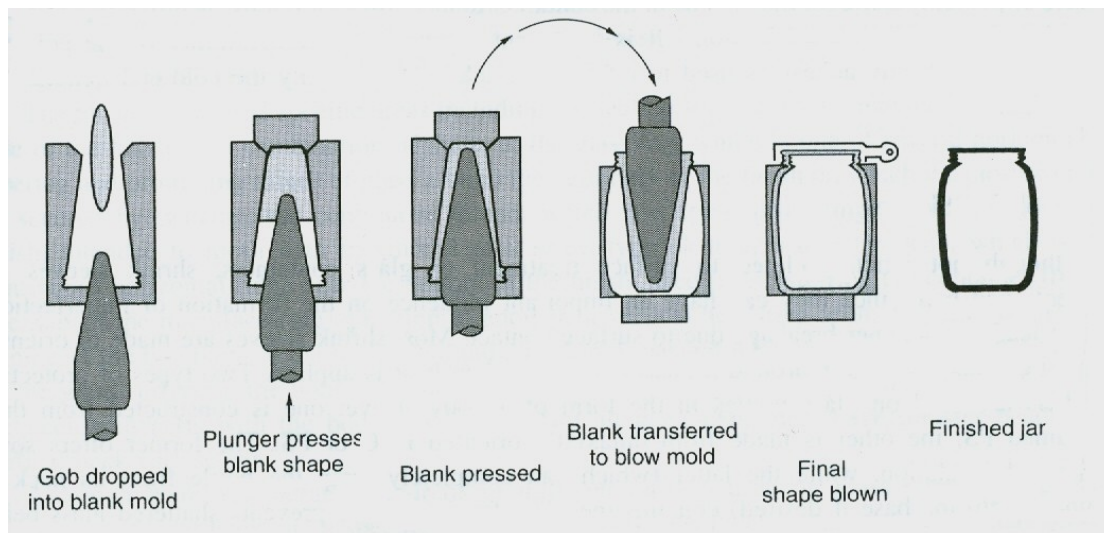
When the finish molding is complete, the plunger is retracted and air blown in from the bottom, enlarging the size of the bubble until the glass is pressed out against the blank mold to form a hollow perform. This is then inverted and transferred to the blow mold where it elongates under its own weight. Air at about 200 kPa or vacuum is applied so that the glass is pressed against the metal surface of the blow mold, which is air cooled to ensure rapid removal of heat. The mold is then opened and the fully blown parison (now at approximately 650°C) is removed and briefly held over a dead plate to allow air to flow up through the dead plate and around the container to further cool it. It is then transported to the annealing lehr.



**Figure 7. Blow and Blow process for glass container manufacture**

## **2. Press and Blow (P&B)**

In the case of jars, a two-step P&B process (Figure 8) is used. The body blank or parison is formed by pressing the gob of molten glass against the mold walls with a large plunger. When the cavity filled, glass is then pushed down into the neck ring and the finish is formed. No baffle or counterblow air is used in the formation of the parison, the operation relying on the mechanical introduction of the plunger into the glass. The rest of the steps in the P&B process are identical to those in the B&B process.



**Figure 8. Press and Blow process for glass container manufacture**

### **3. *Narrow neck press and blow (NNPB):***

NNPB is a more recent process for lightweight bottles, in which the gob is delivered into the blank mold and pressed by a metal plunger.

**C. Annealing** : The term annealing generally refers to the removal of stress, the annealing temperature or point being defined as the temperature at which stresses in the glass are relieved in a few minutes. The containers are transferred from the deadplate to a large oven, known as a lehr, which is equipped with a belt conveyor. The function of the annealing lehr is to produce a stable product by removing any residual stresses resulting from nonuniform cooling rates during forming and handling. This is achieved by raising the temperature of the container to approximately 540°, holding it there for a few minutes and then cooling at a rate that is consistent with the removal of stress from a predetermined wall thickness.

### **Shape of glass container:**

Usually the shape of the container is determined by the nature of the product, each product group having a characteristic shape. Liquid products generally have small diameter finishes for easier pouring; solid products require larger finishes for filling and removing the contents

## Lecture No. 18

*Improvements in glass manufacturing - Hot and Cold end treatment of surface –  
Inspection of Glass Bottles - Advantages and Disadvantages*

### **Improvements in glass manufacturing:**

The strength of a newly made glass container will be reduced by moisture or abrasion. Hence some form of surface treatment has to be given to increase the strength. Two general types of surface treatment are applied to glass containers to modify mechanical properties.

**1. Hot end treatment:** In hot-end treatment (typically carried out while the glass container is at 550°C), vapor containing tin or titanium is brought into contact with the outside of the container, forming a thin unimolecular film of metal oxide. This treatment prevents surface damage while the container is still hot, strengthens the surface and improves the adhesion of the subsequent cold-end coating.

**2. Cold-end treatment:** Cold-end treatment (typically carried out while the glass container is at less than 100°C) is designed to protect the container surface and assist its flow through the filling line. It involves spraying an organic material in an aqueous base containing either waxes, stearates, silicones, oleic acid or polyethylene onto the outside of the container to increase its lubricity by providing a surface with a low coefficient of friction.

### **Inspection of Glass Bottles:**

After annealing operation, the bottles undergo an inspection process.

1. **Squeeze Tester:** Each bottle is passed between discs that exert a force to the body of the container. Any obvious weakness or crack in the bottle will cause it to fail completely with the resulting cullet being collected by a return conveyor running underneath.
2. **Bore Gauger:** The internal and external diameter at the neck finish entrance to the bottle and the bottle height are measured. Bottles outside specification are automatically rejected by means of a pusher positioned downstream from the gauger.
3. **Check Detector:** Focuses a beam of light onto areas of the container where defects are known to occur from previous visual examinations, any crack will reflect the light to a detector, which will trigger a mechanism to reject the bottle.
4. **Wall Thickness Detector:** This test uses dielectric properties of the glass, the wall thickness can be determined by means of a sensitive head which

traverses the body section of the container. A trace of the wall thickness is then obtained and bottles falling below a specified minimum will be automatically rejected.

5. **Hydraulic Pressure Tester:** A test carried out on bottles which will be filled with carbonated beverages and gauges the internal pressure of every bottle before it is packed.
6. **Visual Check:** Bottles are passed in front of a viewing screen as a final inspection.

### **Advantages and disadvantages of glass:**

#### **Advantages:**

- Inert
- Impermeable
- No odour
- Versatility in shape and colour
- Reusable
- Suitable for use in the microwave
- Excellent clarity
- Glass containers are distinctive, convenient and practical
- Glass containers are used for premium quality foods

#### **Disadvantages:**

- Fragile
- Heavy weight
- Expensive

## Lecture No. 19

*Metal as Packaging material - Introduction - Manufacture of Tin Plate - Tin plating*

### **Introduction:**

Four metals are commonly used for the packaging of foods: steel, aluminium, tin and chromium. Tin and steel, and chromium and steel, are used as composite materials in the form of tinplate and electrolytically chromium-coated steel (ECCS), the latter being somewhat unhelpfully referred to as tin-free steel (TFS). Aluminum is used in the form of purified alloys containing small and carefully controlled amounts of magnesium and manganese. Two other metals are used during the soldering or welding of three-piece tinplate and ECCS containers: lead and copper.

Today, materials like tinplate and aluminum have become universally adopted for the manufacture of containers and closures for foods and beverages, largely due to several important qualities of these metals. These include their mechanical strength and resistance to working, low toxicity, superior barrier properties to gases, moisture and light, ability to withstand wide extremes of temperature and ideal surfaces for decoration and lacquering.

### **Manufacture of tinplate:**

Tinplate refers to low carbon mild steel sheet, varying in thickness from around 0.15 to 0.5 mm with a coating of tin between 2.8 to 17 gsm ( $\text{g m}^{-2}$ ) ( $0.4$  to  $2.5 \mu\text{m}$  thick) on each surface of the material. The combination of tin and steel produces a material that has good strength, combined with excellent fabrication qualities such as ductility (the capability to undergo extensive deformation without fracture) and drawability (these attributes arise from the grade of steel selected and the processing conditions employed in its manufacture) as well as good solderability, weldability, nontoxicity, lubricity, lacquerability and a corrosion-resistant surface of bright appearance (these latter properties are due to the unique properties of tin). Furthermore, the tin coating adheres sufficiently to the steel base so that it will withstand any degree of deformation that the steel is able to withstand without flaking.

### ***Tinplating:***

The traditional method for tinplating involved dipping or passing the steel through a bath of molten pure tin, but, since the 1930s, the process of depositing tin by electroplating has been used. The introduction of the electroplating process enabled a different thickness of tin to be applied to the two surfaces of the steel. This "differential tinplate" is of economic benefit to the user because it enables the most cost-effective coating to be selected to withstand the different conditions of the interior and exterior of the container.

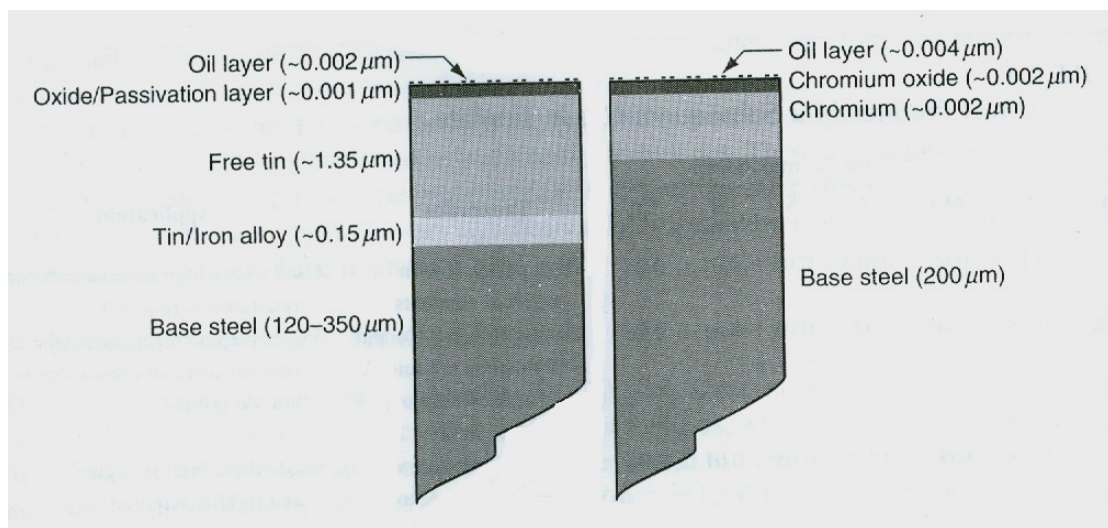
The two principal methods of electroplating are the 1) acid stannous sulfate process (generally known as the Ferrostan process) and 2) the halogen process. Plating by either method is preceded by cleaning in a pickling and degreasing unit, followed by thorough washing to prepare the surface. After the plating stage, the coating is flow melted, passivated and then lightly oiled.

Flow melting consists of heating the strip to a temperature above the melting point of tin (typically 260 to 270°C), followed by rapid quenching in water. During this treatment, a small quantity of the tin-iron compound  $\text{FeSn}_2$  is formed; the weight and structure depend on the time and temperature, as well as other factors such as the surface condition of the steel. The structure and weight of this alloy layer plays an important role in several forms of corrosion behavior.

Because the naturally formed oxide layer on the surface of the tin will readily grow in the atmosphere to form a yellow stain. The steel strip is given a passivation treatment to render its surface more stable and resistant to the atmosphere. An electrolytic treatment in a sodium dichromate electrolyte is used. It results in the formation of a film (usually  $< 0.001 \mu\text{m}$  thick), consisting of chromium and chromium oxides and tin oxides,

The plate is given a light oiling to help preserve it from attack, and to assist the passage of sheets through container-forming machines without damaging the soft tin layer. The oil used is permissible for use in food packaging; cotton seed oil was used for many years but this has now been largely superseded by dioctyl sebacate (DOS) and acetyltributyl citrate (ATBC). These are applied by electrostatic precipitation or direct plate immersion. The strips are sheared into sheets or coiled, and then packed for shipment to the can manufacturers.

The final structure of the completed coating is shown in Figure 9.



**Figure 9. Schematic structure of tinplate and ECCS showing main functional layers**

Tinplate sheets are described in terms of a base box (112 sheets, each 356 X 508 mm).



## Lecture No. 20

|                                                                                       |
|---------------------------------------------------------------------------------------|
| <i>Manufacture of ECCS- - Manufacture of Aluminium - Advantages and Disadvantages</i> |
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### **Manufacture of ECCS:**

Production of electrolytically chromium/chromium oxide coated low carbon steel sheet (ECCS) process involves cathodic deposition in a dilute chromium plating electrolyte (e.g.,  $50 \text{ g L}^{-1} \text{ CrO}_3$  and  $0.5 \text{ g L}^{-1} \text{ H}_2\text{SO}_4$ ) at a temperature in the range 50 to  $70^\circ\text{C}$ . ECCS consists of a duplex coating of metallic chromium and chromium sesquioxide.

Unlike flow brightened tinplate, ECCS is a dull bluish color. However, ECCS is less resistant to corrosion than tinplate as it has no sacrificial tin layer, and therefore must be enameled on both sides. In addition, ECCS containers cannot be soldered with traditional lead or tin solders, and therefore bonding of ECCS components must be by welding or the use of organic adhesives.

### **Manufacture of aluminium:**

Alumina is dissolved in cryolite in carbon-lined steel boxes called pots. Then, a carbon electrode or anode is lowered into the solution and an electric current of 50 to 150 MA is passed through the mixture to the carbon cathode lining of the pot. The current reduces the alumina into aluminum and  $\text{O}_2$ , the latter combining with the anode's carbon to form  $\text{CO}_2$ , while the aluminum (denser than cryolite) settles to the bottom of the pot.

Alloying agents are added to aluminum to impart strength, improve formability characteristics and influence corrosion characteristics. A wide range of aluminum alloys (Si, Fe, Cu, Mn, Cr, Zn, Ti) is commercially available for packaging applications, depending on the container design and fabrication method being used. Commercially pure aluminum is used for the manufacture of foil and extruded containers since it is the least susceptible to work hardening. Type 5182 alloy contains 4 to 5% magnesium and 0.35% manganese, producing a very rigid material suitable for manufacturing beverage can ends.

**Advantages and disadvantages:** Compared with tinplate and ECCS, aluminum is a lighter, weaker but more ductile material that cannot be soldered.

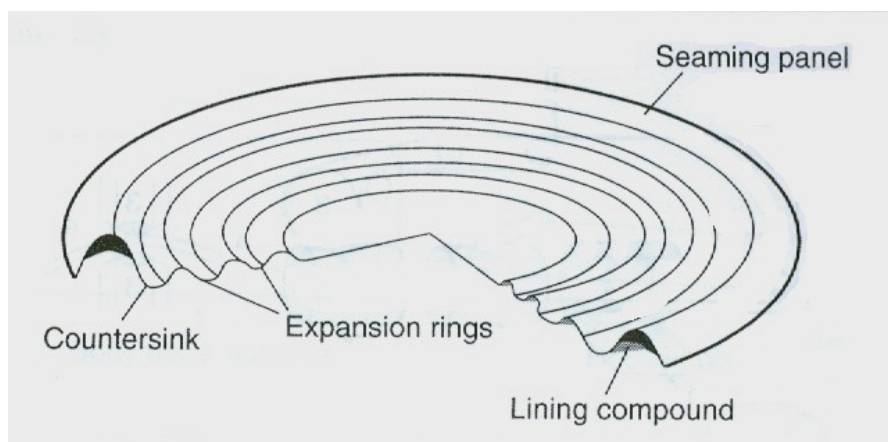
## Lecture No. 21

*Container Making Processes - End Manufacture - Three Piece Can Manufacture - Welded Side seams - Soldered Side seams - Double Seaming - Two Piece Can Manufacture*

### Container – making process:

#### **End manufacture:**

The can end or lid is of complex design developed for optimum deformation behavior, the latter being dependent on plate thickness, the precise contour of the expansion rings and the countersink depth. It is important that the ends are able to deform under internal and external pressure without becoming permanently distorted. In effect, they must act like diaphragms, expanding during thermal processing and returning to a concave profile when vacuum develops inside the can on cooling. The cross-section of a typical end design is shown in Figure 10. The purpose of the sealant is to assist the formation of a hermetic seal by providing a gasket between adjacent layers of metal.

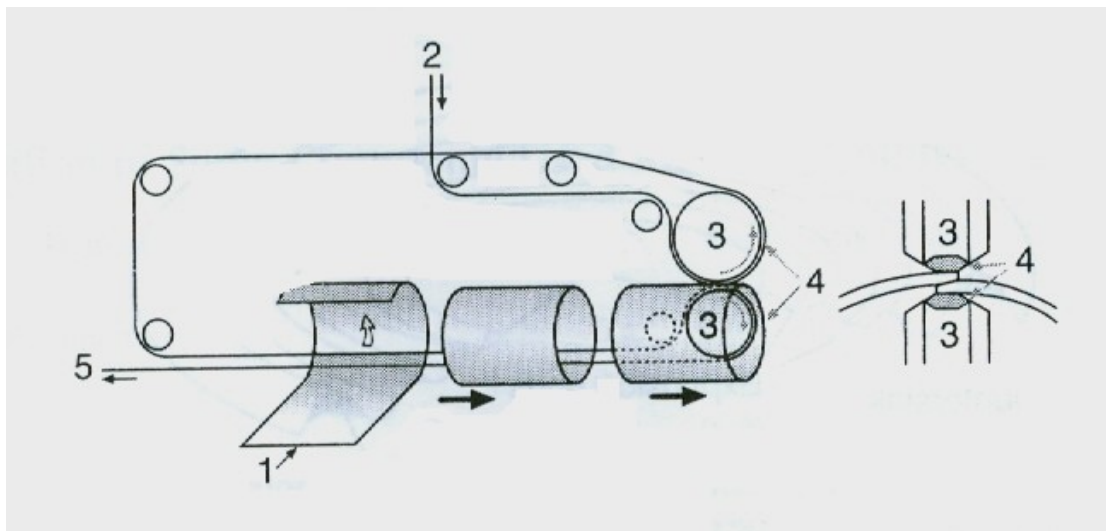


**Figure 10. Profile of a typical can end**

### Three – piece can manufacture:

#### **Welded Sideseams:**

The majority of three-piece tinplate cans currently used for food have welded sideseams. Compared with soldered sideseams, welding offers savings in material, since the overlap needed to produce a weld uses less metal than an interlocked soldered seam. In addition, the sideseam is stronger, it is easier to seam on the ends and a greater surface area is available for external decorating.



**Figure 11. Stages in the formation of a three-piece welded can. (1) Blank rolled to cylindrical shape; (2) Copper wire; (3) Welding electrodes; (4) Copper wire contacts; (5) used wire to recycling**

Prior to welding, sheets of steel are enameled and, if necessary, printed, with the area where the weld will be made left bare. The sheets are then slit into individual blanks. Each blank is rolled into a cylinder with the two longitudinal edges overlapping. The two edges are then welded together.

The wire welded operation currently used for the high-speed welding of tinplate and ECCS containers utilizes a sine wave alternating current (and, in the case of tinplate, a continuous copper wire electrode) to produce a weld with an extremely low metal overlap (0.4 to 0.8 mm). The use of copper wire as an intermediate electrode is necessary to remove the small amount of tin picked up from the tinplate during the welding process, which would otherwise reduce welding efficiency. High electrical resistance causes the interface temperature to rise rapidly to at least 900°C, resulting in solid phase bonding at all locations along the seam (Figure 11). The tensile strength of a good weld is equal to that of the base plate.

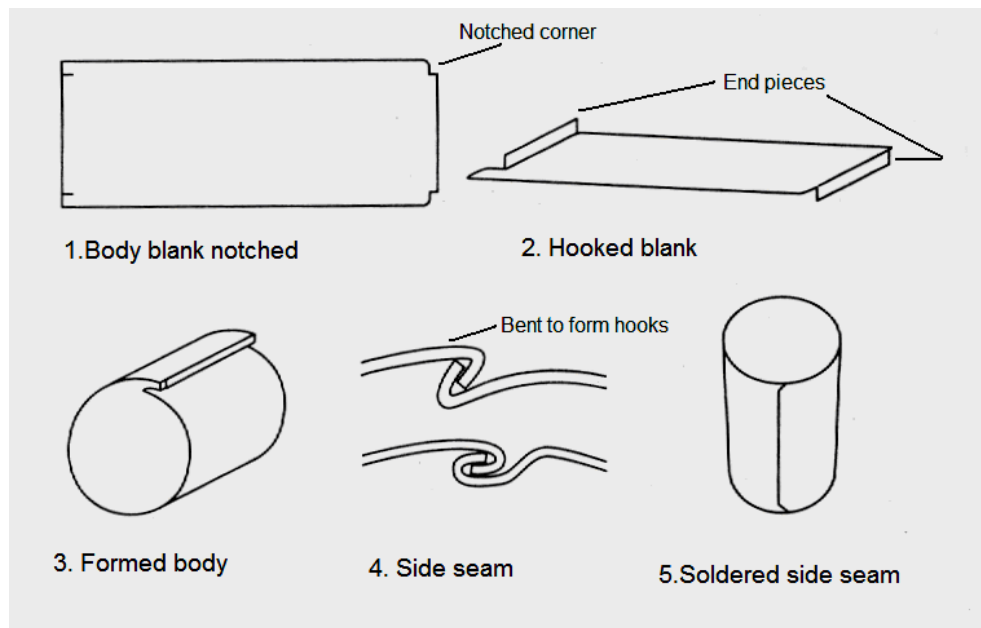
To prevent traces of iron being picked up by some types of beverages and acidic foods, repair side striping (enameling) of the internal surface of the weld is required.

## **2. Soldered side seams:**

Very few food cans are currently produced with soldered side seams. Now-a-days, tin/silver (96:4) solder is used.

The basic steps in the manufacture of three-piece cans with soldered side seams are shown in Figure 12. The coil is first cut into rectangular sheets, which are then enameled and decorated as required, and cut into strips as wide as the

body circumference (including the sideseam) on the first slitting machine. The slit strips are cut into body blanks of the required height, and fed into a body maker where the corners are notched to avoid the extra thicknesses of metal where the sideseam is curled into the end pieces. The two short edges, which will form the sideseam, are bent to form hooks, and the hooked edge is coated with a thin film of flux before being bumped together to create the sideseam.



**Figure 12. Steps involved in the fabrication of three piece soldered can**

The seam area is then preheated by gas jets before passing through a bath of molten solder. Tinplate cans are easily soldered because the tin solder alloy readily fuses with the tin on the surface of the steel. The seam is reheated on leaving the soldering station, the excess solder being wiped off the outside by a rotating mop.

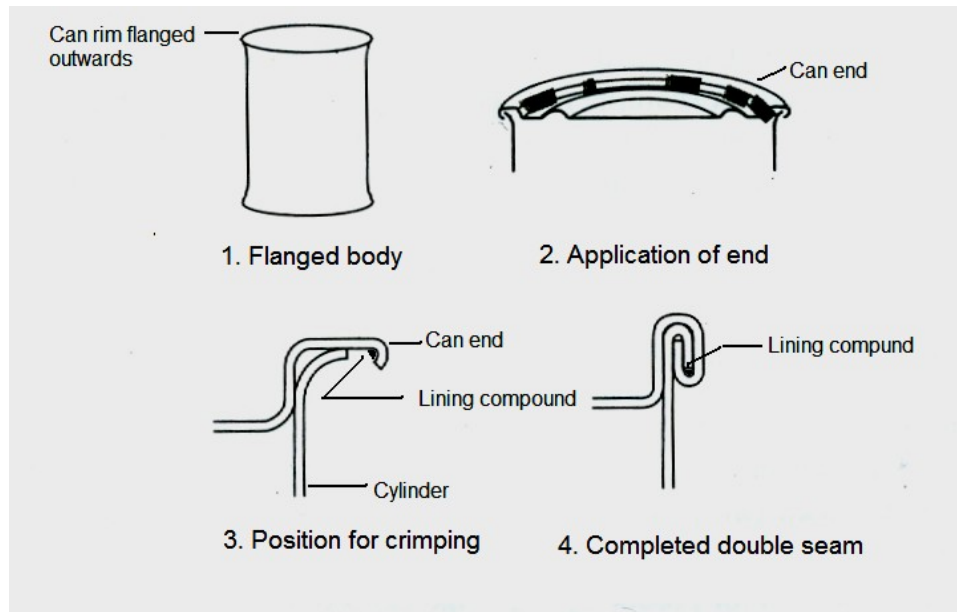
Enamel stripes are then sometimes applied to one or both sides of the seam ("side striping") in an attempt to repair damage made to the previously applied enamel by the heat of the solder. This is essential on beverage cans and those likely to contain highly corrosive products.

#### ***Double Seaming:***

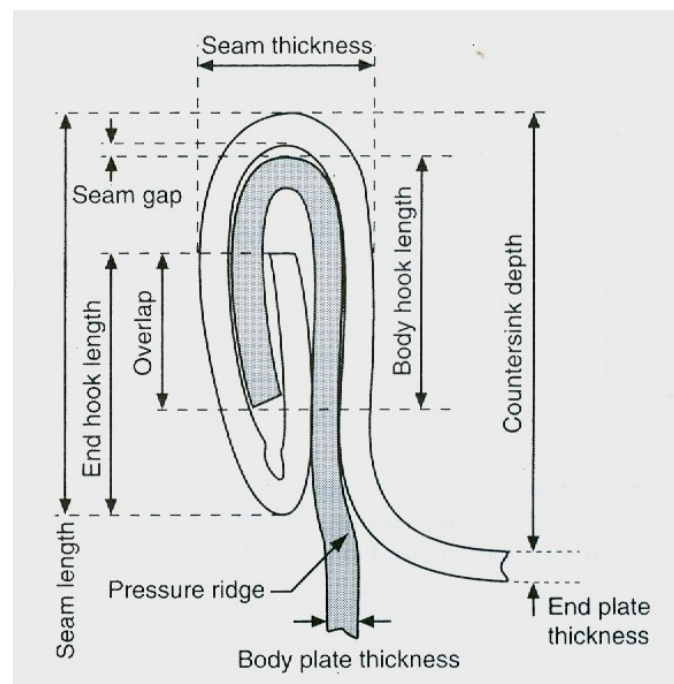
After the sideseam has been formed, the bodies are transferred to a flanger for the final metal forming operation: necking and flanging for beverage cans, and beading and flanging for food cans. The can rim is flanged outwards to enable ends to be seamed on.

The end is then mechanically joined to the cylinder by a double seaming operation. This is illustrated in Figure 13 and involves mechanically interlocking the

two flanges or hooks of the body cylinder and end. It is carried out in two stages. In the first operation, the end curl is gradually rolled inwards radially so that its flange is well tucked up underneath the body hook, the final contour being governed by the shape of the seaming roll. In the second operation, the seam is tightened (closed up) by a shallower seaming roll. The final quality of the double seam is defined by its length, thickness and the extent of the overlap of the end hook with the body hook. The main components of a double seam are shown in Figure 14.



**Figure 13. Double seaming of metal ends on to metal containers**



**Figure 14. Main components of a double seam**

***Two piece can manufacture:***

A major innovation in can making was the introduction of the seamless or two-piece aluminum can in the 1950s and tinplate can in the 1970s.

There are two main methods used commercially to create two-piece cans: 1) the drawn and ironed (D&I) process, which can be adapted to produce a can for pressure packs (including carbonated beverages) and for food containers, and 2) the drawn and redrawn (DRD) process, which is a multistage operation and produces a can mainly suitable for food products.

Two-piece cans have technical, economic and aesthetic advantages in comparison with -soldered or welded three-piece cans. In terms of integrity, the two-piece can has no sideseam and only one double seam, which is more easily formed and controlled because of the absence of a sideseam lap juncture. The internal enamel does not have to protect a soldered sideseam or weld cut edge, and there are material savings in solder and (in the case of D&I cans) plate, the latter being up to 35% lighter than a standard three-piece can. The absence of a sideseam permits all-round decoration of the outside of the can, increasing the effective printing area and leading to a more aesthetically pleasing appearance.

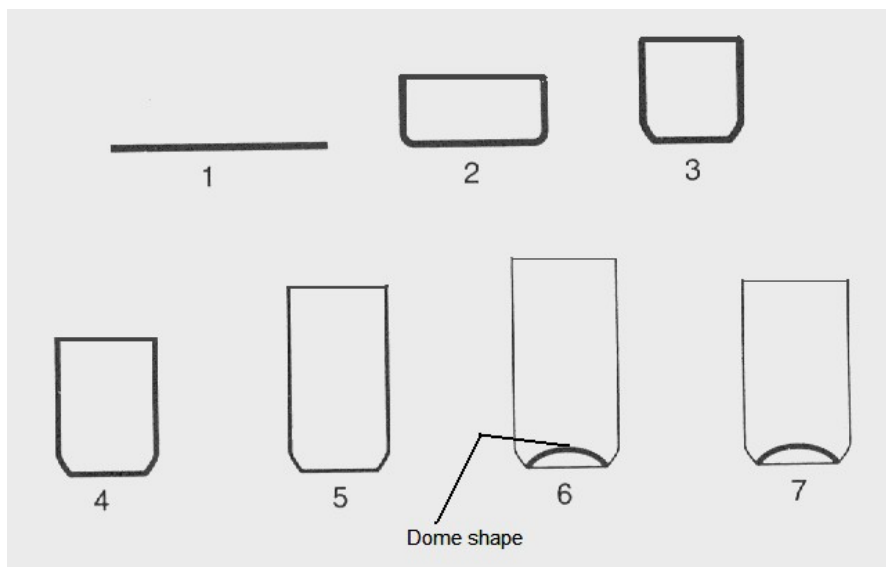
## Lecture No. 22

*D&I Cans - DRD Cans - Protective and Decorative coatings - Aluminium foils and Containers - Tube - Retort Pouch*

### **Drawn and ironed (D&I):**

The D&I (also known as drawn and wall ironed [DWI]) tinplate or aluminum container is made from a circular disc stamped from a sheet or coil of uncoated plate, formed into a shallow cup with effectively the same side wall and base thicknesses as the starting material. The forming process (Figure 15) involves a flat sheet being formed into a cup or cylinder by punch drawing it through a circular die, the wall thickness of the cup being uniform throughout. The plate is covered with a thin film of water-soluble synthetic lubricant prior to forming.

The cup is transferred to an ironing press where it is held on a punch and passed through a series of ironing dies. As a consequence of the ironing process, the wall thickness is reduced (typically from 0.30 to 0.10 mm) and the body height is correspondingly increased. The integral bottom end is domed and profiled to provide added strength, with the end retaining essentially the original sheet thickness. Because the can wall may not iron to the same height all around the circumference due to slight variation in material properties, cans are "overdrawn" and then trimmed to the correct height.



**Figure 15. Sequential stages in the production of two-piece drawn and ironed cans. 1) Disc cut from coil; 2) Drawn into shallow cup; 3) Redrawn into smaller diameter cup; 4), 5), 6) Wall thinning by ironing (diameter remains constant); 7) finished can trimmed to required height.**

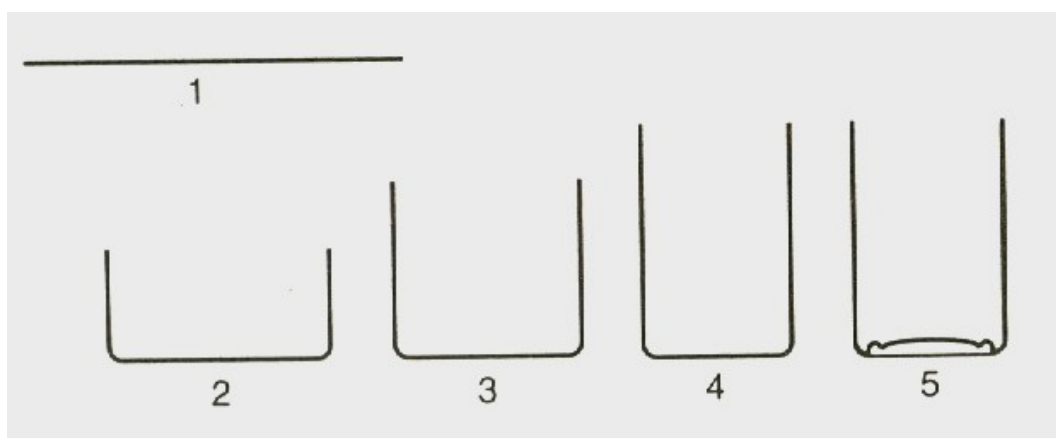
The trimmed cans are chemically cleaned to remove drawing lubricants and to prepare the surface for receiving exterior and interior coatings. If the cans are to be used for beverages, they are then necked; D&I food cans are commonly beaded for added strength against body collapse under partial vacuum conditions. The cans are then flanged.

Tinplate is the best material for D&I cans as the tin coating is soft and ductile and imparts lubricity to the steel while remaining bonded to it throughout. Most D&I aluminium cans are used for beverage packaging (i.e., beer and soft drinks).

***Drawn and Redrawn (DRD):***

DRD process is the use of multistage drawing to produce a can with a higher height-to-diameter ratio. This process (Figure 16) is essentially identical to the initial stages of the D&I technique, except that the final height and diameter of the container is produced by sequentially drawing cups to a smaller diameter - that is, causing metal to flow from the base to the wall of the container rather than ironing the container wall. The wall and base thickness, as well as the surface area, are identical to the original blank.

In the D&I process, the internal diameter of the body remains constant throughout the ironing stages, while the internal diameter of the DRD can is progressively reduced as the height is increased during the various redrawing stages. Prelacquered tinplate and ECCS of 0.2 mm thick are used for the DRD process. DRD cans are currently used in the packaging of food rather than beverages because a greater wall thickness is required to withstand pressure reversals.



**Figure 16. Sequential stages in the production of drawn and redrawn (DRD) cans. 1) Body blank; 2) Drawn cup; 3), 4) Diameter decreases as cup is redrawn; 5) finished trimmed can with profiled base.**



***Protective and Decorative Coatings:***

- They protect the metal from the contents
- They avoid contamination of the product by metal ions from the container
- They facilitate manufacture
- They provide a basis for decoration and product identification
- They form a barrier to external corrosion or abrasion

***Protective coatings:***

For most containers, the enamel is applied to the metal in the flat before fabrication, typical film masses being in the range of between 3 and 9 gsm (4 to 12  $\mu\text{m}$  thick).

Many types of internal enamel are available for food containers including oleoresinous, vinyl, vinyl organosol, acrylic, alkyd, polybutadiene, phenolic and epoxyphenolic

***Decorative Coatings:***

Although the primary purpose in decorating the external surface of a metal container is to improve its appearance and assist its marketability, it also significantly improves the container's external corrosion resistance.

***Aluminum foils and containers:***

Aluminum foil is a thin-rolled sheet of alloyed aluminum varying in thickness from about 4 to 150  $\mu\text{m}$ . It was first produced commercially in the U.S. in 1913 where it was used for wrapping Life Savers candy bars and chewing gum.

Foil can be produced by two methods: either by passing heated aluminum sheet ingot between rollers in a mill under pressure and then rerolling on sheet and plate mills until the desired gauge is obtained, or continuously casting and cold rolling. In the softest temper, aluminum foil exhibits dead fold characteristics - that is, when wrapped around an object it will assume the profile of the object with no springback.

Aluminum foil is essentially impermeable to gases and water vapor when it is thicker than 25.4  $\mu\text{m}$ , but it is permeable at lower thicknesses due to the presence of minute pinholes. For example, 8.9  $\mu\text{m}$  foil has a WVTR of up to 0.3  $\text{mL m}^{-2} \text{ day}^{-2}$  at 38°C and 100% RH.

Aluminum foil can be converted into a wide range of shapes and products including semirigid containers with formed foil lids, caps and cap liners, composite cans and canisters, laminates containing plastic and sometimes paper or paperboard where it acts as a gas and light barrier, and foil lidding.

***Tube:***

The collapsible aluminium tube is a unique food package that allows the user to apply the product directly and in precise amounts when required. Typical applications include condiments such as mustards, sauces and cheese spreads. The aluminium tube is formed by the cold impact extrusion of an aluminum slug using a plunger.

***Retort Pouch:***

The retort pouch is a flexible package, hermetically sealed on three or four sides and made from one or more layers of plastic or foil, each layer having a specific functionality. One of the attractions of the retort pouch compared to the metal can is the thin profile of the package, enabling retorting times to be reduced by up to 60%, final quality to be improved, as well as rapid reheating prior to consumption. Other advantages include the ease of carrying, reheating and serving, as well as weight and space saving. Finally, disposal of the used pouch is much simpler than for the metal can as it can be easily flattened.

Three-layer pouch structure would consist of an outer layer of 12  $\mu\text{m}$  PET for strength and toughness, a middle layer of 7 to 9  $\mu\text{m}$  of aluminium foil as a moisture, light and gas barrier and an inner layer of 70 to 100  $\mu\text{m}$  of CPP for heat sealability, strength and compatibility with all foods. An additional inner layer of 15 to 25  $\mu\text{m}$  of PA is used when a longer shelf life is required.

Unlike the metal can, retort pouches are susceptible to rupture or seal separation during retorting if the internal pressure exceeds the external process pressure. The shelf life of foods packaged in retort pouches is very dependent on storage temperature. If stored at 16°C, then they will last for about 130 months. A recent development has been the incorporation of zippers into the pouch to make it easier to open and reseal.

## Lecture No. 23

*Plastic Consumption in India and World - Plastic packaging material - Classification of Plastics – Advantages and disadvantages*

The plastic consumption in India was 4 million tons and that of the world was 154 million tons during 2005.

### ***Plastic packaging material :***

Plastics are organic polymers which are long chain molecules obtained by addition or condensation of one or more monomers. Polymerization of single repeating unit gives homo polymers and addition of more than one monomer results in co-polymer.

Plastics have become a major packaging material, along with paper, metal and glass. Plastics are used mainly for consumer packages in the form of wraps, pouches, cartons, bags, tubes, bottles, jars and boxes. In transport, they are used in the form of sacks, stretch films for wrapping tray-loads, containing unit packs or for entire pallet loads.

The advent of snack foods, convenience foods and prepared foods has been possible to a great extent due to the availability of plastic packaging materials.

### ***Classification of plastics:***

More than 30 different plastics are used in packaging but the most common ones are polyolefins, polyvinyls and polyesters. They may be divided into *thermosetting* and *thermoplastic* resins.

There are only three thermosets used to any extent in packaging. Phenol formaldehyde and urea formaldehyde are used mainly for bottle closures while glass-reinforced polyesters are used for large containers like storage tanks.

Most of the plastic used in food packaging are thermo plastic, means they can be softened by heating and hardened by cooling. Thermo plastic can be considered chemically as derivatives of ethylene ( $\text{CH}_2 = \text{CH}_2$ ) in which one hydrogenation is replaced by  $\text{CH}_3$ , chlorine, fluorine or phenyl groups. These are often called vinyl plastics as they contain vinyl group ( $\text{CH}_2 = \text{CH}$ ) or poly olefins, since the monomer contain olefin linkage. The main advantages and disadvantages of plastic as food packaging material are as follows.

***Advantages:***

- Barrier to water vapour and gases
- Light weight
- Good strength
- Design flexibility
- Resistance to breakage
- Machinability-high speed filling using form fill and seal techniques
- Glossy and transparent
- Colouring is possible
- High tensile strength
- High tear strength
- High printability
- High level lamination
- Low cost

***Disadvantage:***

The disadvantage of plastic is the disposability i.e. it is difficult to get it disintegrated into soil.

## Lecture No. 24

*Polyethylene - Low Density Polyethylene - Linear Low Density Polyethylene - High Density Polyethylene*

### **Polyethylene:**

It is the polymer of ethylene. It accounts for the biggest proportion of the plastics used in packaging.

#### **1. Low Density Polyethylene (LDPE):**

It is obtained by polymerization of ethylene gas under high pressure of 1000 - 3000 atmospheres and temperature between 100 and 350°C. The density of LDPE film is 910 to 940 kg/m<sup>3</sup>. LDPE is fairly soft, slightly translucent flexible material with waxy feel. It possesses excellent resistance to most chemicals. It is good barrier to water vapour but less to oxygen; has high permeability to volatile oils and swells in contact with fats and oil. It gives very good heat seals and easily coated to other materials and serves as a laminated layer. It is used as bags, liners, bottles etc.

#### **2. Linear Low Density Polyethylene (LLDPE):**

It is generally stronger and tougher than LDPE but has similar properties. The term “linear” in LLDPE is used to imply the absence of long chain branches. Owing to the linearity of its molecules, LLDPE is more crystalline and therefore stiffer, but less transparent than LDPE. LLDPE has higher tensile strength, puncture resistant, tear properties and elongation than LDPE. The density of LLDPE film is 900 to 935 kg/m<sup>3</sup>.

LLDPE combines the main features of both LDPE and HDPE. The advantage of LLDPE over LDPE are improved chemical resistance, improved performance at low and high temperatures, high surface gloss, higher strength at a given density, better heat sealing properties and a greater resistance to environmental stress cracking (ESC).

#### **3. High Density Polyethylene (HDPE):**

HDPE is a nonpolar, linear thermoplastic that possesses a much more linear structure than LDPE. HDPE film is stiffer and harder than LDPE and its density ranges from 941 to 965 kg/m<sup>3</sup>. Tensile and bursting strengths are higher but impact and tear strengths are both lower than LDPE. The chemical resistance of HDPE is superior to that of LDPE and has better resistance to oils and greases. The film offers excellent moisture protection and significantly decreased gas permeability compared with LDPE film, but is much more opaque. Heat sealing is considerably more difficult

compared to LDPE film. HDPE film has a white, translucent appearance and tends to compete more with paper than transparent films.

Polyethylene finds widespread use after extrusion for conversion into wraps, bags and sacks, and blow-moulded forms like bottles and jars, caps, trays, boxes, drums, beverage carriers etc. Oriented and prestretched PE film is used for shrink wrapping.

## Lecture No. 25

*Polypropylene - Polystyrene - Polycarbonate – Polyvinyl Chloride – Polyvinylidene Chloride – Ethylvinyl Alcohol- Polyethylene terephthalate*

### ***Polypropylene (PP):***

Polypropylene is a linear polymer containing little or no unsaturation. PP has a lower density (900 kg/m<sup>3</sup>) and higher softening point (140 to 150°C) than the polyethylenes, low water vapour transmission, medium gas permeability, good resistance to greases and chemicals, good abrasion resistance, high temperature stability, good gloss and high clarity. It can be used where a higher temperature of processing is involved, and for packing readymade food which requires warming before consumption. One of the disadvantages is that the film has a tendency to become brittle at a low storage temperature, a problem which could be overcome by the addition of small amounts of ethylene into the propylene at the time of manufacture.

### ***Polystyrene (PS):***

It is produced by the polymerization of styrene. It is transparent, but has low barrier property. It can be blown, extruded, thermo formed and injection moulded. The material is used for packing vegetables and fresh meat on trays, yoghurt and other milk products in cups, and for the over wrapping of fruits and vegetables. Biaxial orientation gives the film extra strength and toughness and is called oriented-PS (OPS).

### ***Polycarbonate:***

It is glass-like, heat resistant, and sterilisable upto 130°C and is available in the form of film, beside the rigid containers, but has very few food packaging applications.

### ***Polyvinyl Chloride (PVC):***

There are two types – rigid and plasticized. The rigid form has good moisture and gas barrier properties and resistance to fats. Hence, these are used for packing butter or margarine, and for making transparent bottles for mineral water, edible oils, fruit juices, carbonated beverages and beer, as these bottles can withstand pressure.

The plasticised form is used for packing meat, fruits and vegetables and for shrink wrapping. It is also used for the shrink wrapping of pallets.

***Polyvinylidene Chloride (PVdC):***

PVDC has the lowest water vapour, oxygen and CO<sub>2</sub> permeability amongst all commercially used plastic films, besides having resistance to fats and chemicals. PVDC is used as a coating material on polyethylene and other plastics, to improve the gas and moisture barrier properties of the native plastics. It is used for packing dense materials like cheese, poultry etc.

***Ethylenevinyl Alcohol (EVOH):***

EVOH copolymers offer not only excellent processability but also superior barriers to contaminants such as gases, odors, fragrances and solvents. It is these characteristics that have allowed plastic containers containing EVOH barrier layers to replace many glass and metal containers for packaging food. It is widely used polymer in the manufacture of high barrier containers, as in the manufacture of bulk bags used for aseptic packaging, retort pouches and containers.

***Polyethylene Terephthalate (PET):***

PET is a linear, transparent thermoplastic polymer. PET bottles and films are largely amorphous with small crystallites and excellent transparency. PET film's outstanding properties as a food packaging material are its great tensile strength, excellent chemical resistance, light weight, elasticity and stability over a wide range of temperatures (-60 to 220°C). It has low permeability to moisture and gases, but has poor sealing property. Hence, it has to be laminated with PE.

PET containers are used widely for packing mineral water, carbonated and non-carbonated beverages, syrups, edible oils and liquors.



## Lecture No. 26

### Coating - Laminating - Coating process – Laminating Processes

Coating and laminating are two of the most widely used processes for transforming flexible films and sheets into products that have properties useful in food packaging.

*Coating* is the process of applying one or more layers of a fluid or melt to the surface of a material, while *laminating* is the bonding of two or more webs. A *laminate* is defined as any combination of distinctly different plastic film materials or plastic plus non plastic materials (typically paper and aluminium foil), where each major web is generally thicker than 6  $\mu\text{m}$ . There is no upper limit to the possible number of webs, but two is the obvious minimum and one of these must be thermoplastic.

#### **Coating Processes:**

*Extrusion coating* (sometimes called *extrusion lamination*) was first practiced on a commercial scale in the production of LDPE-coated paperboard for milk cartons as a replacement for wax-coated stock. Compared to wax, LDPE is superior with greater strength, seal integrity and resistance to cracking and flaking off. It also provides greater resistance to moisture. Currently, almost all applications for wax-coated paperboard have been replaced by polyolefin-coated paper and board.

Extrusion coating with polyethylene has several advantages over adhesive lamination of a prefabricated polyethylene film to paper. First, thin films of polyethylene are difficult to handle and maintain flat and handling them requires very low tensions, which are difficult to control at high speeds. Secondly, extrusion coating temperatures are sufficiently high so that good mechanical bonds are obtained by resin penetration into the porous paper substrate.

#### **Laminating processes:**

Methods that combine two or more webs by bonding them together are called laminating processes. Bonding is usually accomplished by thermal or chemical means with adhesives and curing systems. After the adhesive is adequately dried or cured, the coated web is combined with an uncoated web through the application of heat or pressure in a nip.

*Thermal laminating* is the joining of two webs with an adhesive that is first applied to land cooled and dried on one of the webs. The webs are heated before pressing them together in the nip of two rollers, which provide the force needed to establish the intimate contact required for the bond. The adhesives most commonly

used are polyolefins such as EVA, and the webs most commonly laminated this way include plastic films, and aluminium foil joined with heat seal coated film or paper.

*Wet bond laminating* uses solvent or aqueous based adhesives and can only be used when one or more of the webs are permeable to the water or other solvent used, thus allowing it to escape. Wet bonding is not generally successful with plastic films, even when laminating them to paper. Usually aqueous adhesives such as casein, sodium silicate, starch, PVA latex, rubber latex or dextrin are used.

*Dry bonding* is considerably more versatile. In that process, any two materials can be laminated once an adhesive system has been developed. Either aqueous or organic solvent based adhesives are used, and they are dried or cured if necessary by the application of heat, prior to laminating. The use of organic solvent base adhesives has been largely phased out because of legislation limiting the release of VOCs (Volatile Organic Compounds) into the atmosphere.

*Solventless laminating* consists of bonding together two webs by curing in the absence of solvents. It has now become the dominant laminating method in commercial use because of legislation limiting the release of VOCs. Single component urethanes are the most widely used; polyester isocyanates are also used.

*Extrusion laminating* is a specialized use of extrusion coating, where a hot extruded film is trapped between two other webs and cooled. This process is used mainly for producing a triple laminate of such materials as paper, aluminium foil, RCF and PET with LSPE, where the latter material is extruded and acts as the bonding agent between the two substrates. As in the case of extrusion coating, this process is applicable to any thermoplastic material, but the technology has been highly developed mainly for polyethylene and associated copolymers, including isomers.

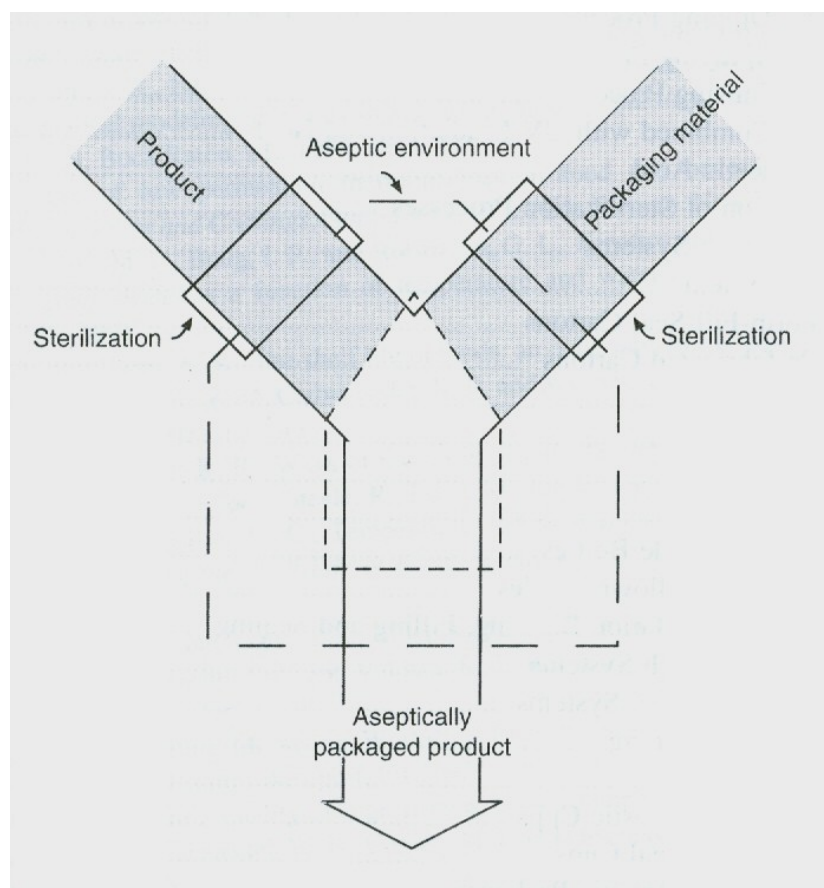
## Lecture No. 27

*Aseptic Packaging – Introduction – Specific fields of application – Reasons for use of Aseptic Packaging – Historical development – Principles of sterilization – Sterilization processes*

### **Introduction:**

*Aseptic packaging* is the filling of sterile containers with a commercially sterile product under aseptic conditions, and then sealing them so that reinfection is prevented; that is, so that are hermetically sealed. Figure 17 illustrates the various aspects of aseptic packaging in diagrammatic form.

The term aseptic implies the absence or exclusion of any unwanted organisms from the product, package or other specific areas, while the term hermetic (strictly air tight) is used to indicate suitable mechanical properties to exclude the entrance of micro-organisms into a package and gas or water vapor into (or from) the package.



**Figure 17. Diagrammatic representation of the aseptic packaging process**

***Specific fields of application:***

- 1) Currently there are two specific fields of application for aseptic packaging:  
Packaging of presterilized and sterile products and
- 2) Packaging of a nonsterile product to avoid infection micro-organisms.

Examples of the first application include milk and dairy products, puddings, desserts, fruit and vegetable juices, soups, sauces and products with particulates. Examples of the second application include fresh products such as fermented dairy products like yogurt.

***Reasons for the use of aseptic packaging:***

The three major reasons for the use of aseptic packaging are:

- 1) To take advantage of high temperature-short time (HTST) sterilization processes, which are thermally efficient and generally give rise to products of a superior quality compared to those processed at lower temperatures for longer times
- 2) To enable containers to be used that are unsuitable for in-package sterilization
- 3) To extend the shelf life of products at normal temperatures by packaging them aseptically.

***Historical Development:***

The first aseptic packaging of food (specifically milk in metal cans) was carried out in Denmark by Nielsen before 1913.

***Principles of Sterilization:***

The Sterilization processes used in aseptic processing are variously described as high temperature short time (HTST) and ultra heat treated or ultrahigh temperature (UHT).

The sterile product is cooled to an appropriate temperature, typically 20°C for low viscous food products like milk and fruit juices, and 40°C for products of higher viscosity such as puddings and desserts.

As aseptic filling system must meet a series of requirements, each of which must be satisfied individually before the whole system can be considered satisfactory. These are:

- 1) The container and method of closure must be suitable for aseptic filling, and must not allow the passage of micro-organisms into the sealed container during storage and distribution.
- 2) The container (or that part of it which comes into contact with the product) must be sterilized after it is formed and before being filled.

- 3) The container must be filled without contamination by micro-organisms either from the equipment surface from the atmosphere surrounding the filler.
- 4) If any closure is needed, it must be sterilized immediately before it is applied.
- 5) The closure must be applied and sealed in place while the container is still within a sterile zone to prevent the passage of contaminating micro-organisms.

### ***Sterilization processes:***

Three main sterilization processes for packaging material are in common use, either individually or in combination: irradiation, heat and chemical treatments.

### ***Irradiation:***

#### ***a) Ionizing Radiation:***

Particle irradiation techniques using gamma rays from cobalt-60 or cesium-137 have been used to sterilize the interior of sealed but empty containers, especially those made of materials which cannot withstand the temperatures needed for thermal sterilization or that, because of their shape, could not be conveniently sterilized by other means. A radiation dose of 25 kGy (2.5 M rad) or more is generally accepted to be sufficient to ensure sterility.

#### ***b) Pulsed light:***

By storing electrical energy in a capacitor and releasing it in short pulses, high peak power levels can be generated. The duration of the pulses ranges from 1 $\mu$ s to 0.1 sec, and the flashes are typically applied at a rate of 1 to 20 flashes per second. Approximately 25% of the emitted light, which has intensity about 20,000 times, that of sunlight at the earth's surface is UV, 45% is visible and 30% is infrared. A few flashes applied in a fraction of a second provide high levels of microbial inactivation.

#### ***c) UV-C Radiation:***

UV radiation has a wavelength of 200 to 315 nm; it is most effective in terms of microbial destruction between 248 and 280 nm (the so called UV- C range) with an optimum effectiveness at 253.7 nm.

### ***Heat:***

Heat sterilization processes can involve either steam (moist heat) or dry heat. Steam is much more efficient than dry heat. Steam sterilization at 121°C for 20 min is equivalent in effectiveness to dry heat sterilization at 170°C for 60 min.

### ***Chemical treatments:***

Hydrogen peroxide has lethal effect on micro-organisms.

Peracetic acid (PAA) is a liquid sterilant, which is particularly effective against spores.

## Lecture No. 28

Aseptic packaging system – Carton, Can, Bottle, Sachet and Pouch, Cup systems -  
*Advantages of Aseptic Packaging*

### **Aseptic packaging system:**

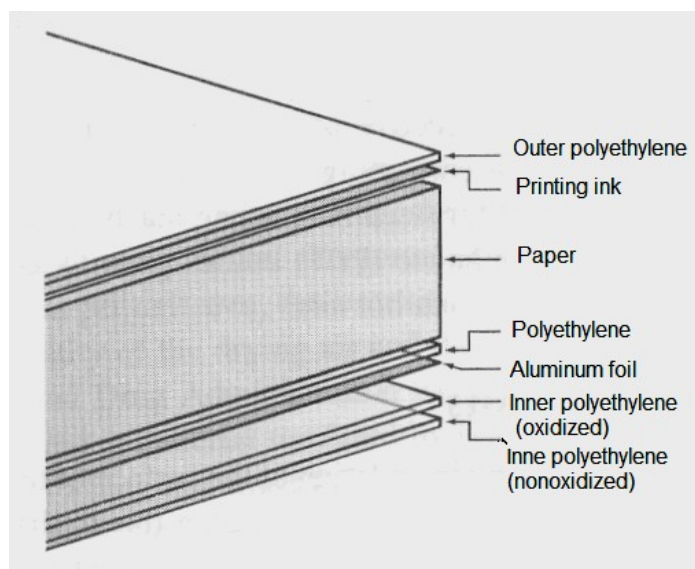
The aseptic packaging system must be capable of filling the sterile product in an aseptic manner and of sealing the container hermetically so that sterility is maintained throughout the handling and distribution processes. An aseptic packaging system should be capable of meeting four criteria:

1. Able to be connected to the processing system in a manner that enables aseptic transfer of product to take place.
2. Able to be effectively sterilized before use.
3. Able to carry out the filling, sealing and critical transfer operations in a sterile environment.
4. Able to be cleaned properly after use.

The most widespread consumer package for aseptic products is the paperboard laminate carton. Five major categories of aseptic packaging equipment are available and their major features and characteristics are described below.

### **1. Carton systems:**

The carton material consists of layers of unbleached or bleached paperboard coated internally and externally with polyethylene, resulting in a carton that is impermeable to liquids and in which the internal and external surfaces may be heat sealed. There is also a thin (6.3  $\mu\text{m}$ ) layer of aluminum foil which acts as an  $\text{O}_2$  and light barrier. The structure of a typical paperboard carton is shown in Figure 18.



**Figure 18. Typical structure of a paperboard laminate carton for aseptic filling**

The functions of the various layers are:

1. The outer polyethylene ( $15 \text{ gm}^{-2}$ ) protects the ink layer and enables the package flaps to be sealed.
2. The bleached paperboard ( $186 \text{ gm}^{-2}$ ) serves as a carrier of the decor and gives the package the required mechanical rigidity.
3. The laminated polyethylene ( $25 \text{ gm}^{-2}$ ) binds the aluminium to the paperboard.
4. The aluminium foil ( $6.3 \mu\text{m}$ ) acts as a gas barrier and provides protection of the product from light.
5. The two inner polyethylene layers ( $15 \text{ gm}^{-2}$  and  $25 \text{ gm}^{-2}$ ) provide a liquid barrier

***Form fill seal cartons:***

The packaging material is supplied in rolls that have been printed and creased, the latter being necessary to ease the forming process. A plastic strip is sealed to one edge and the packaging material sterilized using a wetting system or a deep bath system.

In the wetting system, a thin  $\text{H}_2\text{O}_2$  film (15 to 35% concentration) containing a wetting agent to improve the formation of a liquid film is applied to the inner packaging material surface. The material then passes through a pair of rollers to remove excess liquid and under a tubular electric heater, which heats the inside surface to about  $120^\circ\text{C}$  and evaporates the  $\text{H}_2\text{O}_2$ .

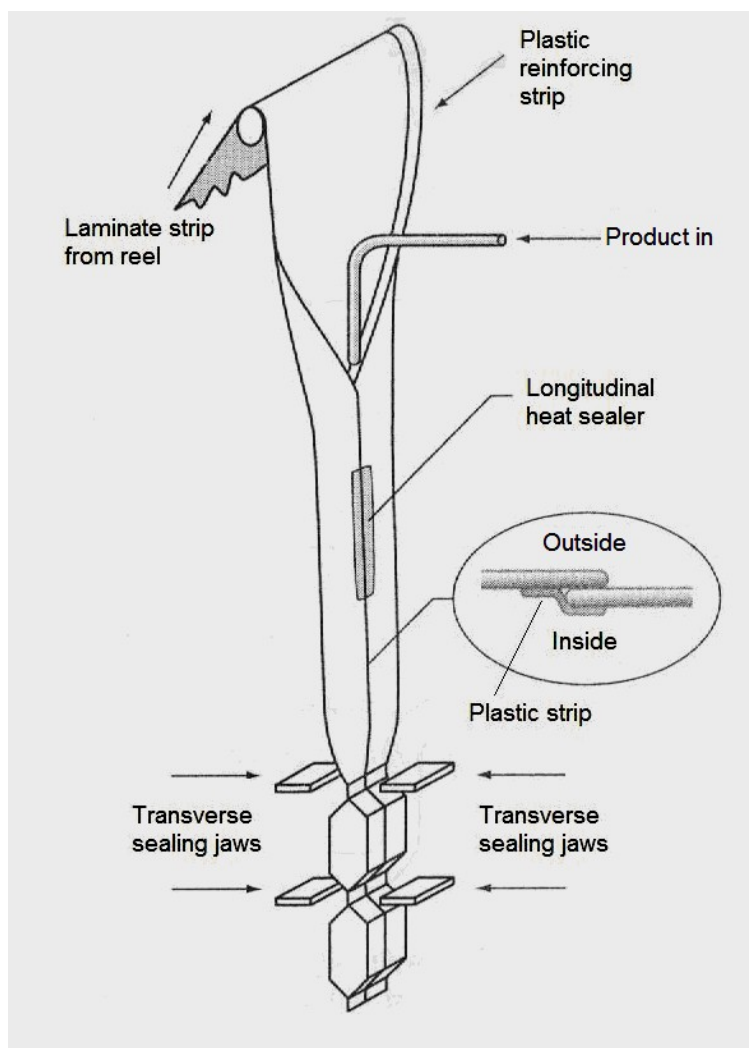
In the deep bath system, the packaging material is fed through a deep bath containing  $\text{H}_2\text{O}_2$  (35% concentration) at a minimum temperature of  $70^\circ\text{C}$ , the residence time being 6 sec. After squeezer rollers have removed much of the peroxide, both sides of the material are heated with air (directed through nozzles) at a temperature of  $125^\circ\text{C}$  to evaporate the peroxide.

The sterilized packaging material is fed into a machine where it is formed into a tube and closed at the longitudinal seal by a heat sealing element. In the process, the strip that was added prior to sterilization is heat sealed across the inner surface of the longitudinal seal to prevent contact between the outside and the inside of the carton. It also provides protection of the aluminum and paperboard layers from the product, which could corrode or swell the layers if such a strip were absent.

The tube is then filled with the product and a transverse seal made below the level of the product, thus ensuring that the package is completely filled. Alternatively, the packages may be produced with a headspace of up to 30% of the total filling

volume by injection of either sterile air or other inert gases. The sterilization, filling and sealing processes are all performed inside a chamber maintained at an overpressure of 0.5 atm with sterile air.

The method of forming cartons from a continuous web is shown in Figure 19. The sealed packages are then pressed by molds into rectangular blocks, after which the top and bottom flaps or wings are folded down and heat sealed to the body of the package using electrically heated air.

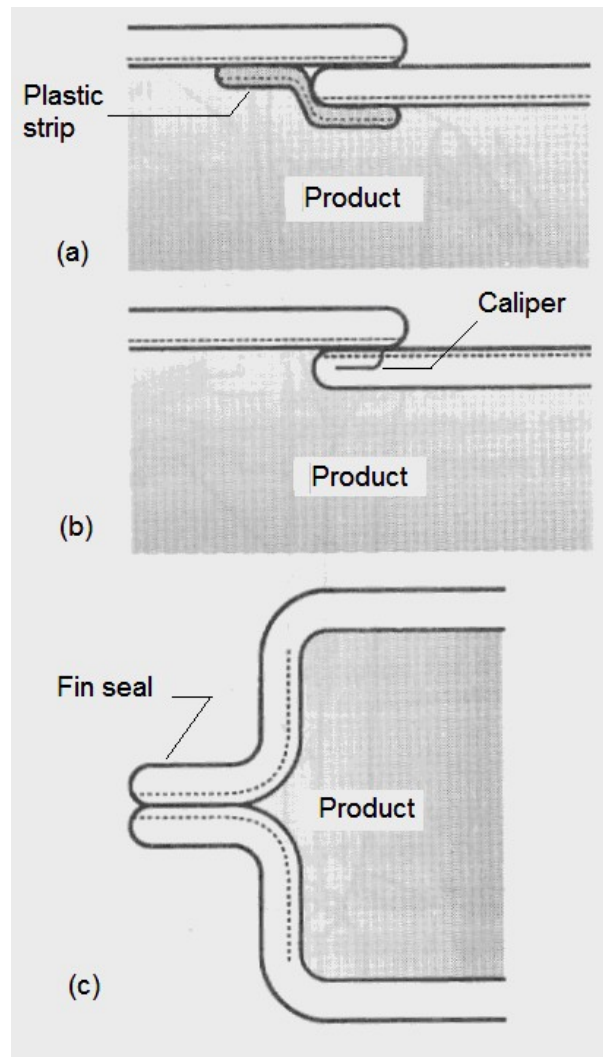


**Figure 19. Method of forming cartons from a continuous web; the cross-section of the longitudinal seal is enlarged to show the polyethylene strip which protects the internal edge of the carton**

#### ***Prefabricated carton:***

In this type, prefabricated carton blanks are used, with the cartons being die-cut, creased and the longitudinal seam completed at the factory of origin by skiving the inner layer of board and folding it back (Figure 20).





**Figure 20. Three types of side seams used with aseptic paperboard laminate cartons: (a) Plastic strip overlaps internal side of longitudinal seam (as used with form-fill-seal cartons); (b) inner layer of board is skived (pared down) and the reduced-caliper edge is folded back and sealed off from the product (as used with prefabricated cartons); (c) fin seal which avoids exposure of the product to any cut edges of paperboard**

The aseptic area of the filling machine consists of several separate functional zones where operations are carried out in sequence. Sterility is maintained in each zone by a slight over pressure of sterile air. The inside surface of the carton is sterilized with a 35% solution of  $H_2O_2$  delivered either a fine spray or peroxide vapour in hot air. The peroxide is removed by a jet of hot air at 170 to 200°C. Alternatively, the inside of the carton can be sprayed uniformly with 1a 1 to 2% solution of  $H_2O_2$  and then irradiated for approximately 10 sec with high intensity UV radiation. The peroxide is then heated and removed by hot air jets.

The next stage of the process is filling. A certain amount of headspace is always advisable to ensure that the package can be opened and poured without spilling. A headspace is essential when the contents require shaking (as is the case with flavored milk drinks and pulpy fruit juices). It is advantageous to fill the area between the product and the top of the package with steam or an inert gas such as  $N_2$  for products such as fruit juices.

The carton top is folded and closed after filling, where the seal is made by either induction heating or ultrasonic welding. Production and date codes are added afterwards with ink-jet printing or by burning into the top seam. The protruding flaps or "ears" on each side, are folded down and sealed to the package with hot air.

## **2. Can system:**

The system for cans was pioneered by W.M. Martin in the late 1940s and in 1950 the first commercial aseptic filling machine was commissioned by the James Dole Corporation in California for soups. This system uses superheated steam at temperatures of up to  $225^{\circ}C$  for up to 40 sec to sterilize the cans and can ends. The three basic types of metal cans (tinplate, electrolytically chromium coated steel (ECCS) and aluminum) can be used in this system

After the cans are filled with the cold, sterile product they are sealed using a conventional can seamer which has been modified for aseptic operation. Superheated steam is used to maintain asepsis during the filling operation and this results in a high vacuum in the can. To prevent excessive vacuum in the can which could lead to leakage or spoilage, either sterile air or  $N_2$  is blown into the headspace of the can immediately prior to seaming; this results in a vacuum of about 275 mm Hg compared with 500 to 600 mm Hg without air injection.

An additional important packaging-related factor concerns the lining compound in the lid. At the seaming temperature of  $220^{\circ}C$  it is very plastic, and for this reason the seamed can must be transported in an upright position for at least 15 sec to allow the compound to settle down and hermetically seal the can. Only then may the can be rinsed to remove filling residues or transported by rolling.

Composite cans consisting of a spirally wound body made from laminations of foil, plastics and paper with metal ends are sterilized using hot air at  $143^{\circ}C$  for 3 min. The use of steam to sterilize composite cans is not practicable since swelling of the paper layers would result.

## **3. Bottle systems:**

**a) Glass:** The bottles were sterilized with either saturated steam under pressure or dry heat. When the latter process was used, extended cooling with sterile

air was required to minimize the risk of bottle breakage from thermal shock when bottles were filled with cool product.

**b) *Plastics:*** Blow molded plastic bottles have been used for many years as a cheaper alternative to glass for nonreturnable containers. High density polyethylene (HDPE) and Polypropylene (PP) are the two most common thermoplastics used, sometimes with pigments added so the contents are better protected from light.

#### **4. *Sachet and pouch systems:***

Form-fill-seal system and lay-flat tubing systems are available under this category.

#### **5. *Cup systems:***

Preformed plastic cups and form-fill-seal cups are available under this system.

#### ***Advantages of Aseptic packaging:***

Aseptic processing allows better use of packaging materials and systems. Unlike conventional canning, aseptic processing causes less thermal damage to the product and less stress on the packaging. Besides improving product quality, it allows the use of materials other than the traditional metal can or glass jar. Although cans and jars are used in aseptic processing, laminated paper board or plastic containers of various shapes may be used which reduce the cost of the packaging material.

## Lecture No. 29

*Machineries used in Food Packaging – Twist wrapping – Bread wrapping- Horizontal form fill sealing machine*

A package is designed to protect and to sell the product it contains and this generally requires a mechanical process on a packaging line selected to carry out efficiently those operations necessary to put the product into the package.

The majority of the operations on a packaging line are concerned with the package itself, such as making or forming sachets, erecting or closing cartons, feeding and seaming cans, and presenting bottles to filler heads and capping them. Secondary operations such as coding, labeling, detecting metal, check weighing and collation for dispatch, also involve the package in the main. The packaging line must put the product in the package economically, in the desired condition, at the required speed and to the stated quantity. The nature of the product will have a more profound effect on the performance of the packaging line than any other factor. The machinery must be selected to accommodate the variations in dimensions and in critical properties) that will inevitably occur in both product and package.

The principal factors which affect efficiency and utilization of a packaging line may be considered under three headings:

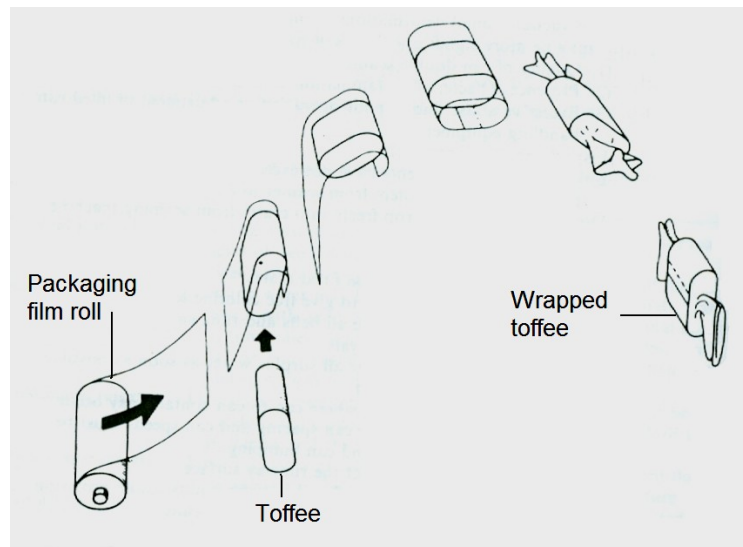
1. The suitability of the machine for the purpose.
2. The output speed required.
3. The likelihood and frequency of stoppages and the time taken to clear them.

The machineries such as twist wrapping and bread wrapping are used to wrap toffees and bread respectively.

### ***Wrapping operations:***

#### ***Twist wrapping of toffees:***

Automatic wrapping machines replace the manual operator for wrapping mass-produced articles in a constant flow. The speed of packaging is greatly increased and in the case of small objects such as toffees which are convenient to feed and wrap, speeds of up to 600 pieces per minute may be achieved by cutting a piece of film, forming it into a tube around the object and twisting the ends of the tube (Figure 21). This is known as twist wrapping.

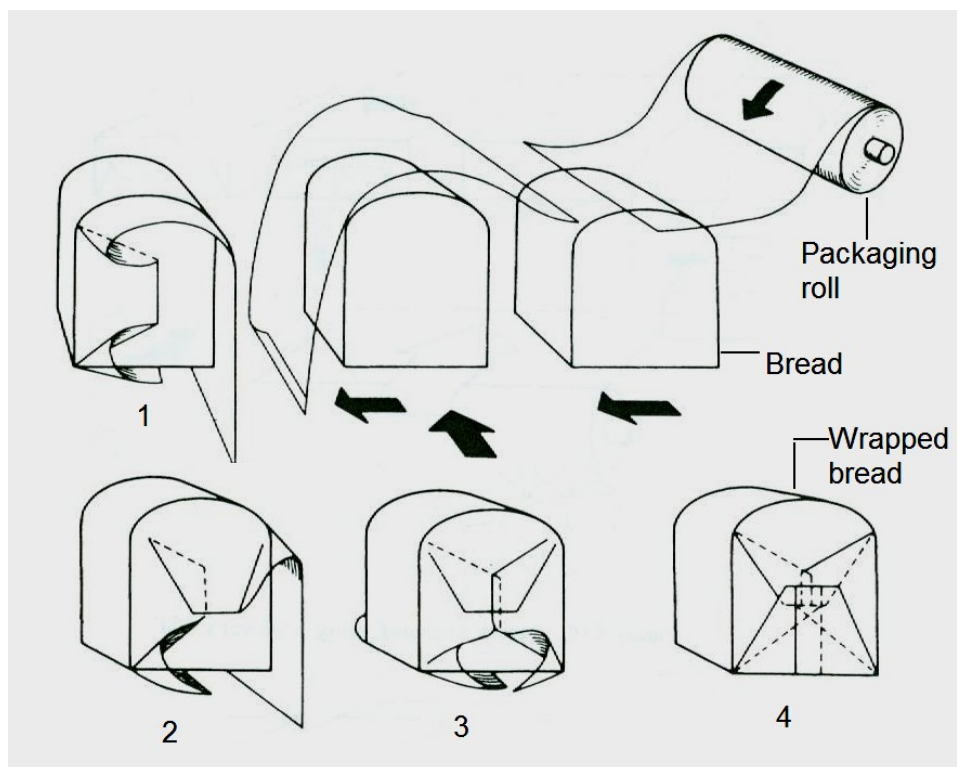


**Figure 21. Twist wrapping of toffees**

### ***Bread wrapping:***

The principle of the bread-wrapping machine (Figure 22) produces a direct wrap using material drawn from the reel. The product is fed by a flighted conveyor through a curtain of heat-sealable material on to an elevator. The wrapper is gripped between the product and a keep-plate on the elevator, and the first end-fold is made. As the elevator moves upwards, the wrapper is pulled from the reel, formed around the loaf and the second end-fold is made. By using the product to pull-feed the wrapper, the length of film used is determined by the product girth. This is particularly useful for bread which varies somewhat in size from loaf to loaf. The wrapper is separated by a serrated knife as the loaf is moved forward by reciprocating pusher. The third and final end-folds are formed and the base longitudinal seam is made. This and the end-folds are then heat-sealed and the wrapped loaf is discharged by belt conveyors.

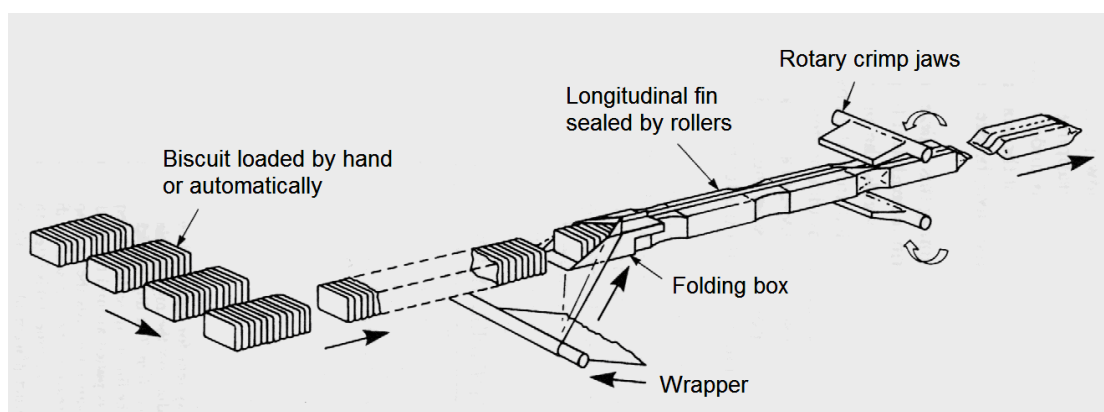
Waxed paper and heat-sealable cellulose films can be used with the standard machine and provision is available to use polyethylene and cast polypropylene. Sealing of the plastic films is achieved using heated discharge belts.



**Figure 22. Bread wrapping**

***Horizontal form fill sealing (ffs) machine:***

For wrapping biscuits on edge, in single column, machines are equipped with overhead transport-fingers on the in feed and with special side belts to hold the biscuit column in position after passage through the folding box (Figure 23).



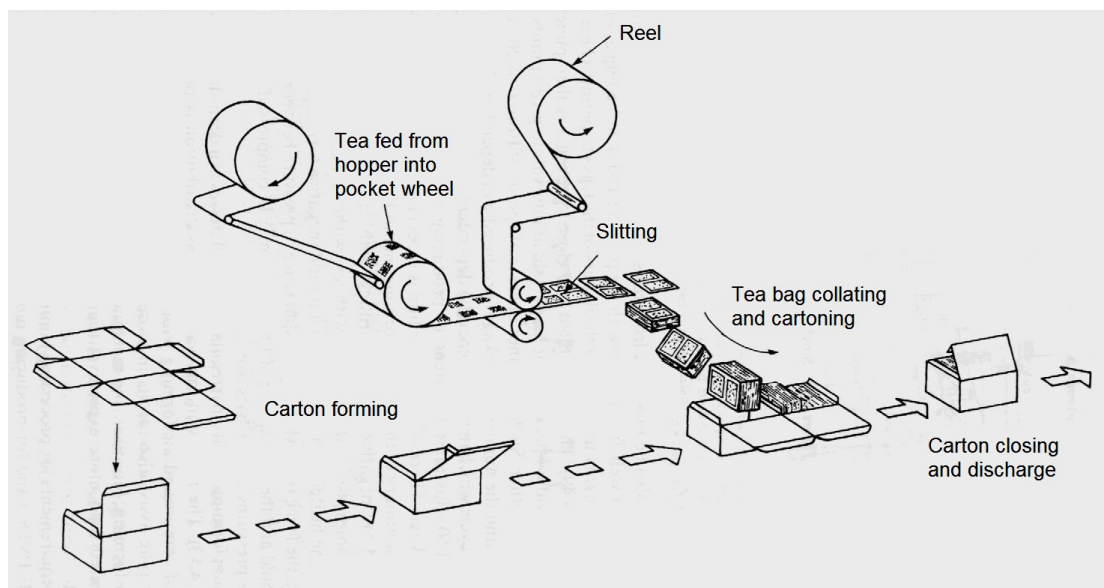
**Figure 23. Horizontal f.f.s. machine. Biscuit wrapping machine**

### Lecture No. 30

*Sequence of operations of a basic twin web machine - Sequence of operations of a basic single web machine - Packaging of Biscuits, , Milk Powder, Coffee - Carbonated soft drink- Fried Snack Foods*

#### **Sequence of operations of a basic twin web machine:**

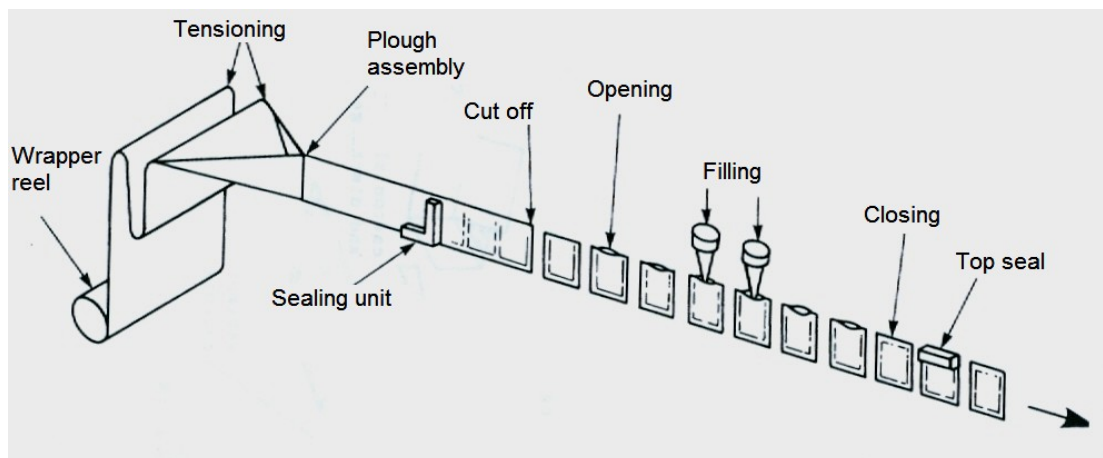
The sequence of operations of a basic twin web machine is shown in Figure 24. Wrapping material is drawn, in a horizontal plane, simultaneously from two reels. Material from one reel overlays that from the second reel. The product is introduced between the two layers. The edges of the two layers are then sealed together, cross seals are then made between each product, and the individual packs so produced are cut off. Cartons will be moving on a belt conveyor and the required number of tea bags will be dropped in it. Finally the carton will be closed and discharged.



**Figure 24. Sequence of operations of a basic twin web machine**

#### **Sequence of operations of a basic single web machine:**

Material is pulled off from the reel in a horizontal plane, over a forming shoulder (plough or nose) (Figure 25). The shoulder guides the material in such a way as to fold it in half, with the open portion towards the top. The folded material is drawn through a series of sealing stations, forming a three side seal. Individual packs are then cut and the material advanced for product filling and closure.



**Figure 3. Single web sachet packaging**

### ***Packaging of various food items:***

#### ***Biscuit:***

Most biscuits are wrapped in BOPP (bioriented polypropylene) film, commonly known as OPP. For the less demanding application, an OPP monofilm is sufficient. For higher quality products, duplex OPP or OPP combinations such as OPP/PE, OPP/PET, OPP/PVdC in the appropriate thickness and sealing range are more effective. They offer effective barrier against gas, odour and light. The wrapping material with the highest barrier properties is aluminium foil, say 7 micron with is often used in combination with PET or syrlene.

#### ***Milk powder:***

Aluminium foil laminates like paper/polyethylene are excellent for retail packs. Vacuum packaging in oxygen impermeable flexible film laminates is better than tin containers with inert gas for whole milk powder in terms of shelf life and quality. Whole milk powder and infant foods require vacuum or gas packing to prevent oxidation of fat.

#### ***Coffee:***

The major deteriorative reaction in coffee is *staling*, thought to result from a loss of flavor volatiles or chemical changes in the volatile components caused by moisture and O<sub>2</sub> absorption. Many flexible laminates used for hard packs used to contain a central layer of aluminium foil but this has been replaced in many situations by a metallized layer. A typical early construction was 12  $\mu\text{m}$  PET – 12  $\mu\text{m}$  Al foil – 70  $\mu\text{m}$  LDPE, while contemporary structures are metallized PET laminated to LDPE.



***Carbonated soft drink:***

Today, the greatest volume of soft drinks is packaged in PET bottles. The PET bottle is usually fitted with either a standard aluminium roll-on closure or a prethreaded plastic cap, both either in the standard or pilfer-proof form.

***Fried Snacks foods:***

Fried snack foods are typically packaged in multilayer structures, although spiral wound, paperboard cans lined with aluminium foil or a barrier polymer and sealed under vacuum with an LDPE-foil end are used for some specialty products that also require mechanical protection. In addition, the use of metal cans for fried nuts is popular for premium products, where the container is usually gas flushed with  $N_2$  immediately prior to seaming. The use of metallized films is widespread and although they are reasonably efficient light barriers, they do permit some light to penetrate into the package.

## Lecture No. 31

*Package Testing - Thickness – Paper density - Basis weight – Grammage*

### **Package Testing:**

Package testing must be performed under standard conditions (see ISO 2206 or BS 4826 pt.2). All packages should be tested in a controlled atmosphere, generally 23°C, 50% rh.

### **Thickness:**

Thickness of a material is the perpendicular distance between the two outer surfaces of the material. Many physical properties of packaging materials are dependent upon the thickness e.g. Water Vapour Transmission Rate (WVTR) and Gas transmission Rate (GTR) of a film is inversely proportional to thickness and decrease with increase in thickness.

Dial gauge, micrometer, screw gauge, vernier calipers are used for the measurement of thickness. For paper boards, thickness is reported in points or in mm (1 point = 1/1000 of an inch); for papers it is in mm or inches. For films, thickness is reported in micron, mils or in gauge (25 micron = 1mil = 1/1000 of an inch = 100 gauge = 0.25 mm).

### **Paper density:**

**Paper density** (also known as **basis weight** and **grammage**) is a term used in the pulp and paper industry to denote a measure of mass of the product per unit of area for a type of paper or paperboard.

The term "density" is not used in its traditional sense of mass per unit volume. "Paper density", rather, is a measure of the area density. Paper density can also be used to distinguish paper from paperboard as the latter usually has a grammage greater than 224 g/m<sup>2</sup>.

Two ways of expressing paper density are commonly used:

- Expressed in grams per square meter (g/m<sup>2</sup>), paper density is also known as **grammage**. This is the measure used in most parts of the world.
- Expressed in terms of the mass (expressed as weight) per number of sheets, it is known as **basis weight**. The convention used in the United States and a few other countries using US paper sizes is pounds of a ream of 500 (or in some cases 1000) sheets of a given (raw, still uncut) basis size. Japanese paper is expressed as the weight in kg of 1000 sheets.

## Lecture No. 32

*Burst Strength - Tear Resistance - Tensile Strength - Grease Resistance - Gas Transmission Rate (GTR) - Water Vapour Transmission Rate (WVTR)*

### **Burst Strength:**

The test measures the ability of a paper or paper board to withstand pneumatic or hydraulic pressure built up. For films, foils, laminates and papers, the pneumatic test is used. Heavy papers and paper boards are tested on hydraulic type of testers (lbs/sq. inch or kg/sq. cm). The test gives a sort of combined tear and tensile properties. In many cases it serves as good index of the quality of fabrication of packaging materials.

### **Tear Resistance:**

The papers are tested for their tearing resistance properties in two ways:

**Internal tearing:** The energy required to propagate an internal tear is measured.

**Edge tearing:** The energy required to initiate a tear is measured.

The test is done on both directions of the paper. The work done in tearing is measured by the loss in potential energy of the pendulum of the instrument.

$$\text{Tear Factor} = \frac{\text{Tearing resistance in grams}}{\text{Basic weight in GSM}}$$

(GSM = gram/square meter)

### **Tensile Strength:**

The tensile strength of a paper is defined as the force applied parallel to the plane of the specimen of specified width and length under specified condition of loading. The test indicates the durability and serviceability of papers in many packaging operations such as wrapping, bagging, printing etc. Plastic films are normally tested at higher speeds because of higher extensibility. The stress strain curve helps in locating the yield point and knowing the yield strength

### **Grease Resistance:**

Grease resistance is measured by exposing one of the test specimen creased to grease containing red dye. The time required for the red stain to show on the unexposed side is taken as a measure of this property. For plastic films, the test can be performed directly in pouches using groundnut oil coloured with red Sudan dye.

### **Gas Transmission Rate (GTR):**

The gas transmission rate is normally determined by measuring the change in pressure at constant volume. The quantity of gas flowing across the film is compiled as volume at NTP (Normal Temperature and pressure). GTR is an important property

to estimate the efficiency of the packaging material or a package resistance to the flow of gases and helps in selection of barrier materials for oxygen sensitive foods.

***Water Vapour Transmission Rate (WVTR):***

The WVTR is measured as the quantity of water vapour in grams that will permeate from one side to other side of the film of an area of one square meter in 24 hours, when the relative humidity difference between the two sides is maintained at 90 per cent gradient at 37.8°C. The property is important to estimate the efficiency of the packaging material or a package for resistance to the flow of water vapour and is helpful in considering the selection of barrier materials for hygroscopic foods.

***Impact Strength:***

These tests are designed to measure the ability of the films to withstand fracture by shock the test is a measure of toughness of the material. It is a combination of deformation and breaking properties.

***Abrasion Resistance:***

This test is designed to measure the ability to withstand surface wear and rubbing. It is a measure of some mechanical properties like hard resilience. The procedure consists of abrading the sample with a wheel of standard abraide for a definite number of revolutions and finding the weight loss of the sample.